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# Compatibility matters: Assessing the risks of built heritage cleaning

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**Compatibility matters: Assessing the risks of built heritage cleaning**

*To my Parents*

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# Abstract

Today, heritage conservation is a discipline torn between the objectivity of its material questions and the subjectivity of its stakeholders and practitioners, inherent to the fact that conservation is, first and foremost, a cultural act.

Most current conservation perspectives advise for (conservation) decisions to be based on the significance of the heritage object. Following this approach, different management tools have emerged to assist conservation at site, local, national and international levels. Quite the opposite, in what concerns interventions, conservation is still largely viewed as an objective material problem, and decision-support tools at this level are still mainly focused on performance assessments. An exception to this rule is the Eight-step Planning Model, complemented by the (In)compatibility Assessment Procedure, proposed by Delgado Rodrigues & Grossi, which attempts to bridge the gap between the macro and micro levels of heritage conservation planning.

Compatibility has been gathering momentum as a conservation principle, but it has been mostly dealt with from a purely material perspective and is still insufficiently defined, especially in scopes beyond product testing. Borrowing from the aforementioned (In)compatibility Assessment, the research presented herein argues that compatibility is an adequate operative concept to assist decision making and guide conservation interventions. The key for using the principle of compatibility at this level of heritage conservation is to link it to the significance of the (conservation) object. This is demonstrated by proposing a procedure for the planning of built heritage cleaning based on the assessment of its risks towards significance; using risk analysis as a development tool, this procedure intends to frame the subjectivity of decision making in heritage cleaning.

From this research, it follows that the principle of compatibility may constitute a valuable bridge between the objectivity and the subjectivity of heritage conservation.

Keywords: cultural significance / compatibility / risk assessment / planning procedure / built heritage cleaning

# Resumo

A conservação do património é, hoje em dia, uma disciplina fortemente dividida entre a objectividade das suas questões materiais e a subjectividade dos seus actores, inerente ao seu indiscutível carácter de acto cultural.

Actualmente, as perspectivas para a conservação recomendam a centralização das decisões na significância do objecto patrimonial. Neste contexto, têm surgido diferentes instrumentos de apoio à decisão aos níveis do sítio, local, nacional e internacional. No entanto, ao nível das intervenções, as ferramentas de apoio à decisão são sobretudo baseadas em avaliações de desempenho, uma vez que a conservação é ainda largamente vista como um problema de materiais. Exceptua-se a esta regra o modelo de Planeamento das Oito Fases, complementado pelo processo de Avaliação de (In)compatibilidade, proposto por Delgado Rodrigues & Grossi, que tenta preencher a lacuna entre os níveis macro e micro do planeamento na conservação do património.

O conceito de compatibilidade tem vindo a ganhar importância como princípio de conservação, mas tem sido sobretudo abordado numa perspectiva material, não estando ainda suficientemente definido, especialmente em âmbitos além do teste de produtos. A partir da supramencionada Avaliação da (In)compatibilidade, a investigação aqui apresentada defende que, dentro das tendências actuais da conservação, a compatibilidade é um conceito operativo adequado para apoiar a tomada de decisão e orientar as intervenções de conservação, desde que conjugado com a significância do objecto patrimonial. Para demonstrar esta premissa, é proposto um procedimento para o planeamento de intervenções de limpeza em património construído, baseado na avaliação dos riscos de limpeza para a significância do objecto; desenvolvido com recurso a ferramentas da análise de riscos, este procedimento visa enquadrar a subjectividade da tomada de decisão na limpeza do património.

Decorre desta investigação que o princípio da compatibilidade pode constituir uma ponte valiosa entre a objectividade e a subjectividade da conservação do património.

Termos-chave: significância cultural / compatibilidade / avaliação de riscos / procedimento de planeamento / limpeza do património construído

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*Restoration is an effort that consumes the brain and never leaves your soul to rest. This great venture is composed of an infinity of details, that eventually become obsessing; moreover, it is necessary to maintain an exact balance between the demands of archaeology and of the picturesque, of statics and of aesthetics. Such a balance is often impossible to meet. One has to make choices: to lean towards one side or the other.*

Camillo Boito in *Conservare o Restaurare,* 1893

*Our ancestors restored statues; we remove from them their false noses and prosthetic devices; our descendants will, in turn, no doubt do something else. (…)*
*The great lovers of antiquities restored out of piety. Out of piety, we undo what they did. (…)*
*Of all the changes caused by time, none affects statues more than the shifts of taste in their admirers.*

Marguerite Yourcenar in *Le Temps, Ce Grand Sculpteur*, 1983 (transl. Walter Kaiser)

# Abbreviations

| | |
|---|---|
| AHD | Authorized Heritage Discourse |
| AS/NZS | Standards Australia International/Standards New Zealand |
| BLfD | Bayerisches Landesamt für Denkmalpflege (Bavarian State Conservation Office) |
| BSI | British Standards Institution |
| CBA | Cost-Benefit Analysis |
| CEN | Comité Européen de Normalisation (European Committee for Standardization) |
| CHAN | Cultural Heritage Agency of the Netherlands |
| CIs | Compatibility Indicators |
| CMC | Carboxymethyl cellulose |
| CMN | Canadian Museum of Nature |
| COE | Council of Europe |
| CVM | Contingent Valuation Method |
| DIP | Digital Image Processing |
| DSS | Decision Support System(s) |
| ECCO | European Confederation of Conservator-Restorers' Organisations |
| EDTA | Ethylenediaminetetraacetic Acid |
| EGUP | Engineering Geological Usefulness Parameter |
| EH | English Heritage |
| EHP | (Queensland Department of) Environment and Heritage Protection |
| EN | European Norm |
| FAO/WHO | Food and Agriculture Organization of the United Nations / World Health Organization |
| FBSL | Fuzzy Buildings Service Life |
| FOM | Fibre-Optic Microscopy |
| FS | Fraction Susceptible |
| GCI | Getty Conservation Institute |
| GIS | Geographic information system |
| HWMPC | Hadrian's Wall Management Plan Committee |
| H@R | Heritage at Risk Programme |
| ICATHM | International Congress of Architects and Technicians of Historic Monuments |
| ICCROM | International Centre for the Study of the Preservation and Restoration of Cultural Property |
| ICOMOS | International Council on Monuments and Sites |
| ICOMOS – ISCS | International Council on Monuments and Sites – International Scientific Committee for Stone |

| | |
|---|---|
| IEC | International Electrotechnical Commission |
| IPHAN | Instituto do Patrimônio Histórico e Artístico Nacional (Brazilian National Institute for Historic and Artistic Heritage) |
| IPSN | Institut de Protection et de Sûreté Nucléaire (French Nuclear Safety and Protection Institute) |
| LNEC | Laboratório Nacional de Engenharia Civil (Portuguese National Laboratory for Civil Engineering) |
| LP | Laser Profilometry |
| MSCV | Monastery of Santa Clara-a-Velha (Coimbra, Portugal) |
| NDT | Non-Destructive Testing |
| NGO | Non-Governmental Organization |
| OED | Oxford English Dictionary |
| OM | Optical Microscopy |
| OUV | Outstanding Universal Value |
| PM | Project Management |
| PMI | Project Management Institute |
| PRODOMEA | PROject on high compatibility technologies and systems for conservation and DOcumentation of masonry works in archaeological sites in the MEditerranean Area |
| PRM | Project Risk Management |
| QDEHP | Queensland Department of Environment and Heritage Protection |
| RCE | Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency of the Netherlands) |
| RILEM | International Union of Laboratories and Experts in Construction Materials, Systems and Structures |
| SBMK/ICN | Stichting Behoud Moderne Kunst / Instituut Collectie Nederland (Foundation for the Conservation of Modern Art / Netherlands Institute of Cultural Heritage) |
| SEM | Scanning Electron Microscopy |
| SEM/EDS | Scanning Electron Microscopy / Energy Dispersive X-Ray Spectroscopy |
| TEM | Transmission Electron Microscopy |
| UNDRO | Office of the United Nations Disaster Relief Co-ordinator |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| UNI | Ente Nazionale Italiano di Unificazione (Italian Standards Institution) |
| V&AMCD | Victoria & Albert Museum Conservation Department |
| WHS | World Heritage Site(s) |
| WTA | Willingness-To-Accept |
| WTP | Willingness-To-Pay |

# 1. Introduction

*A beginning is the time for taking the most delicate care that the balances are correct.*
Frank Herbert in *Dune*, 1965

Heritage conservation, especially in its managerial sphere, has been approached in the West, for the past decades, from a values-led perspective. This approach to conservation was firstly theorized by Alois Riegl in 1903, but it only truly gained momentum in presiding over conservation decisions from the last quarter of the 20th century onwards. Several value systems have since been proposed for the significance assessment of conservation objects, but, apart from a few notable exceptions, they are seldom integrated in material-based research or on the planning of heritage conservation interventions. As Mason noted, "Historic preservation [termed heritage conservation in Europe] theories and *tools* need to reflect the notion that culture is an ongoing process, at once evolutionary and inventive—not a static set of practices and things" (2004: 70); also, attention has been drawn to the excessive discrepancies between theory and practice in heritage conservation (Dümcke & Gnedovsky 2013). Hence, it could be argued that there is room for conservation-interventions planning to better mirror societal trends in the tending of heritage, and particularly for bridging the gap between the material and immaterial issues raised by interventions upon heritage objects.

Need for constant improvement notwithstanding, conservation interventions today are (already) generally characterized by a vast extent of subjects and issues that need addressing, as well as by the correspondingly large array of methodologies and processes involved. This vastness often poses relevant approaching difficulties, not only from a scientific viewpoint, but also at a practical application level. For these reasons, both feasibility and performance of conservation and restoration interventions are, recurrently, difficult to ascertain, plan for, or assess. On the other hand, the increasing level of multidisciplinary work involved in conservation projects, although undeniably beneficial, often lacks a systematic structure or frame integrating the available information. Hence, it seems that all the different parties involved would benefit from an assessment framework allowing for a more structured planning and thus a more efficient resource allocation, particularly in the analysis of large-scale interventions, such as those concerning the built heritage.

Heritage objects are non-renewable resources and therefore, whichever level of conservation is considered (national, local, site, or intervention), "tragic choices", i.e., "choices in which the sacrifice of some value is inevitable" (van de Vall 1999: 196) are, they too, inevitable. Where interventions are concerned, such choices only too often rest upon a (very) limited number of planners, who do not necessarily possess the required expertise nor are allowed the resources needed for scientific consulting. In such circumstances, decision making is highly subjective

and poorly justified at best; at worst, the heritage object is put at serious risk, and some of its values may be irreversibly lost.
Transparency, accountability, inclusiveness and rationality are increasingly demanded from conservation experts and institutions; holistic and integrating approaches should thus be sought to respond to these demands from the outset of conservation planning – so as to ensure, as much as possible, that the balances are correct.

### Statement of the problem

The research presented in the current dissertation tries to answer the following question: How can compatibility serve as an operative concept to reduce subjectivity in heritage conservation decision making?

The choice of this topic surfaced with the proposal of a methodology designed to assess and evaluate conservation interventions, which uses compatibility as key operative concept (Delgado Rodrigues & Grossi 2007). One of the goals of this dissertation was to determine the validity of this compatibility-based approach in the analysis of conservation and restoration interventions. Although this determination could arguably be extended to any type of heritage object, this work is mainly focused on built heritage assets.
Considering recent trends in the conservation field towards policies that prioritize more integrated decision making, the current study aims at providing tools for enhancing analysis and communication within conservation interventions, and thus a more efficient resource management; the obtained results are furthermore expected to promote an increasingly quality-based approach at planning level, raising the demands for good conservation practice. Significant cultural (and economic) benefits may potentially be gained with a more holistic approach to heritage conservation, so that it more adequately meets the constantly renewed challenges and perspectives brought about by ever-changing societies and contexts.

### Aim & objectives

Ultimately, the aim of this dissertation is to answer the aforesaid question, i.e., to ascertain the conditions under which *compatibility* may function as an operative principle to guide conservation interventions. To accomplish this task, the following sequence of objectives was envisioned:

1. Understanding what are the goals and principles directing conservation interventions today;
2. Understanding the contexts, concerns and implications of the usage of *compatibility* as a conservation principle and, from there, defining it in the scope of this research;
3. Investigating the decision-support systems available for planning heritage conservation, especially the aforementioned (in)compatibility assessment process, and assessing their validity and possible limitations;
4. Investigating if/how those systems may be improved by the current research;
5. Investigating the applicability of risk assessment in the operationalization of the compatibility principle;
6. If pertinent, proposing an addition to the (in)compatibility assessment process that aptly operationalizes the compatibility principle, subject to the goals of heritage conservation;
7. Validating the undertaken research.

All objectives, except for the last two, were pursued resorting to a critical analysis of conservation and risk assessment literature; a procedure was developed by applying the information found relevant, which was validated by an expert panel. The implementation of these objectives resulted in a dissertation structure that is briefly outlined in the following section.

### Chapter organization

For compatibility to function as an operative concept in the planning of conservation interventions, it is important to clarify what are the goals of said interventions, in order to verify if a compatibility approach will assist in reaching those goals. Chapter 2 is thus devoted to a review of pillar concepts and principles that preside over conservation decisions today, including the role of compatibility; considering some of the uses of the term in the (built heritage) conservation field allowed proposing a definition to guide the ensuing research.

The methods upon which this dissertation was built are briefly introduced in Chapter 3, including two methods for decision-making support in architectural heritage conservation interventions. In 2007, 'compatibility' was operationalized into a DSS (Decision Support System) for the planning of built heritage conservation interventions (Delgado Rodrigues & Grossi 2007; PRODOMEA n.d.); this DSS provided the background for the developed work; while remaining an inescapable reference for decisions on material choices, this DSS was found lacking the elements necessary for its application to the planning of (built heritage) cleaning actions, which constitute a relevant step in many conservation interventions. This lacuna is filled by the research presented herein, which develops a wider framework for 'compatibility' to function within conservation planning; the entire development process is described, hoping not only to assist potential users, but also to inform further research in adapting this framework to conservation planning for different heritage-object typologies.

Approaching the planning of built heritage cleaning started with an analysis of its specific goals, issues and the definition of 'cleaning compatibility'; these are described in Chapter 4. Operationalizing the concept of 'compatibility' into a decision-guiding principle was achieved via the assessment of the incompatibility risks that may arise in cleaning interventions performed upon built heritage. A risk assessment essentially amounts to identifying, analysing and evaluating the risks entailed by a given project or plan; thus were the risks of cleaning assessed in terms of their incompatibility towards the heritage object. A risk is a combination of likelihood and consequences of damage occurring; in the present context, damage corresponds to an incompatible outcome. All factors contributing to either the likelihood or the consequences of this damage must be identified and analysed, so that the risk may be estimated and evaluated. The risk analysis is developed in Chapter 5, followed by the risk evaluation in Chapter 6.
Chapter 7 is dedicated to the validation of the obtained results. This validation was achieved via the consultation of an purposely convened expert panel, using the Delphi Method to structure group communication.
Finally, a few conclusions and further research directions are presented in Chapter 8.

### Key assumptions & scope delimitation

The concepts and principles described in Chapter 2, and by extension the tools and reasoning presiding to the remainder of the work, are chiefly pertinent in the context of Western/European culture, and do not necessarily coincide with the ones that guide conservation in societies with traditions rooted in different civilizations or nations. The valorization (and the valuing) of objects deriving from different systems of thought, and hence being conceptually distinct, will originate different approaches to the conservation of these values. The choice of conservation guidelines or methods will inherently stem from and incorporate each culture's approach to conservation objects and, accordingly, decision-making processes are described here from a Western perspective as well. This means that the results and proposals integrating this dissertation require a careful analysis and thorough understanding of the stakes before they are applied in differing contexts.
On the other hand, and although it is suggested that the thought process presented here may be transposed to support decisions pertaining to different object typologies, the proposed tools and applications were developed specifically with built heritage objects in mind. While adaptations

of these proposals to stone objects other than buildings, including sculpted or archaeological artefacts, will be able to borrow many of the reasonings that are put forward below, again a careful analysis of object-typology specificities is recommended before hasty applications are undertaken. Furthermore, it should be highlighted that polychromy was not considered as a variable in this analysis; to consider it would have raised another level of complexity to the developed procedure that would have been unnecessary before it was ascertained if the procedure was a valid one; therefore, adaptations should be made before applications on built heritage objects with polychromy are pondered.

Finally, it cannot be overstated that the procedure proposed herein was intended as a reasoning-supporting tool and not as a collection of rigid rules: as all heritage stewards are well aware, "every case must be judged in its own merits" (Ashley-Smith 2009: 15) and, as such, built heritage intervention planners are encouraged to analyse the procedure thoroughly, so that sensible adaptations to each case may be proposed and duly justified.

### Additional remarks

The term 'conservation' is mostly used throughout this dissertation in its broadest sense, i.e., encompassing research, planning and technical actions undertaken with the ultimate goal of managing change to heritage objects so that their significance is maintained or increased. The the term 'conservation object' generally refers to tangible heritage assets and is used interchangeably with 'object', 'site', or 'heritage object/site'. These and other key terms are defined for use in this dissertation in a Glossary that may be found at the end of the main text, i.e., after the Conclusions Chapter.

Unless otherwise indicated, all quotations from sources in French, Italian, Portuguese or Spanish correspond to personal translations. This dissertation uses Oxford spelling.

# 2. Fundamentals of heritage conservation

*... the things of the world have the function of stabilizing human life, and their objectivity lies in the fact that – in contradiction to the Heraclitean saying that the same man can never enter the same stream – men, their ever-changing nature notwithstanding, can retrieve their sameness, that is, their identity, by being related to the same chair and the same table.*

Hannah Arendt in *The Human Condition*, 1958 (quoted in Lipe 1984)

Heritage may be defined as a "«social construct», juridical and memorial" (Leveau 2012: 14); or, arguably more inclusively, as a "cultural practice, involved in the construction and regulation of a range of values and understandings" (Smith 2006: 11). As a cultural practice, heritage is human defining at its very core:

> Heritage is always cultural heritage. But "cultural" must be seen in the fullest sense of that word: it is not just that we may share the culture of art and refinement; it is that "the primary difference between our species and all others is our reliance on cultural transmission of information". This is "culture" in the anthropological sense as that which defines human society. It takes us to the very foundation of what it is to be human. (Adam 2008: 4, with a quotation from Dennet)

To any individual or community, heritage fulfills a crucial "identifying function" and its material expression constitutes "a fundamental device […] in the anchoring of human societies in the natural and cultural space and in the double temporality of humans and nature" (Choay 2011: 16). On the other hand,

> A sense of identity must inevitably draw on a sense of history and memory – who and what we are as individuals, communities or nations is indelibly formed by our sense of history and the way individual and collective memory is understood, commemorated and propagated. (Smith 2006: 36)

And, in the practice of heritage today, conservation plays a leading role.

Despite being a relatively new discipline, heritage conservation has known various shifts during the past decades, mirroring both societal attitudes towards history and heritage and lessons learned from new findings and experience.

The first decade of the 21st century marks a turning point in conservation theory, namely "a philosophical shift from scientific objective materials-based conservation to the recognition that conservation is a socially constructed activity with numerous public stakeholders" (Richmond & Bracker 2009: xv-xvi). Indeed, the role of natural sciences in the understanding of decay processes and of the best forms of dealing with them in each unique case prompted an ever-firmer bond between conservation and these sciences, both technology- and methodology-wise. Nevertheless, the objectivism of hard sciences and technology could not provide an adequate theoretical support for conservation, since it placed its emphasis uniquely on the materiality of the object and it did not necessarily acknowledge the ground reasons behind the act of conservation (Mason 2004), nor did it contemplate the role of the diverse stakeholders involved in each given conservation intervention. The progressively stronger connections between conservation and the social sciences were therefore a logical evolution: "Historically linked to the fine arts, and afterwards connected to the experimental sciences, the true place of restoration is in the field of social sciences. It is there that it should settle to reinvent the methodologies that will give a sense to the activity." (Leveau 2011: 9) Somewhat less drastically, Michalski had already raised this issue a few years prior:

> Our responsibility is to our biological inheritance as perceptive, active, emotional beings and our social inheritance as knowledgeable, cultured beings, as influenced by objects. We must roughly understand the paradigms of the researchers who study these inheritances and then convince some of their better players to take an interest in our problems. (1992: 257)

Also, in recent years, the evolution in conservation trends has reflected the strong development of (1) cultural tourism, which can act as a financing source for the preservation and protection of cultural heritage; and (2) the rehabilitation of historic buildings and urban centres, which may contribute to the financing of some preservation actions as well (Moropoulou 2000a). For conservation to cope with these new challenges entailed "the employment of new tools, like planning and management of the integral natural, human and cultural environment in the direction of a sustainable maintenance" (Moropoulou 2000a: 78). The question remains, however, if these tools are sufficient: under the guise of a phenomenon parallel to that of heritage, tourism has been claimed to, in fact, "condition, guide and enfold the concept of heritage and the strategies for its conservation, designation and rehabilitation" (Gilman 2015: n.p.). And if the current context of heritage lies within a "logic of globalizing capitalism" (Gilman 2015: n.p.), then one of the most relevant social impacts to conservation derives from today's ever pressing need for the rational and sustainable use of resources:

> rational decision-making with regard to cultural heritage requires us not only to *understand*, *define*, and *identify* cultural heritage but to *justify its preservation* on the grounds that (a) its survival is essential to the spiritual and emotional well-being of human beings and (b) it contributes handsomely to our economic well-being. (Burman 2001: 21)

From a different standpoint, Matero argued that many current developments of the heritage conservation discipline are dictated by historicist perspectives. This influence may be viewed as the direct consequence of the emergence of a need for the "stabilizing effect objects and places have by connecting us to a personal and collective past" (Matero 2003: 1) in response to today's fast-paced cultural environment. As remarked by Matero, it is precisely this need, as presented by "public taste, tourism and economic development opportunities" (Matero 2003: 2) that 'justifies and sustains' the historicist perspective commonly imparted today to heritage conservation, resulting in a "commodification of heritage in all its forms – as objects, places, people, events and even symbols – for recreational, economic and political purposes". This position is seconded by Choay, who vehemently alerts against the perils of this "museumization and commercialization of heritage" (2011: 44). Also concerned with this museumization, Matero adds,

> this [historicist] approach has tended to isolate places from their contemporary physical and social context, often ignoring the continuing significance that such structures and landscapes hold for many communities in defining and preserving everyday life and values in all their diverse forms and expressions. (2003: 1)

This stance is reiterated by Smith (2006) and by Poulios: "heritage conservation, formed and still operating in this context of dissatisfaction with the present, creates discontinuity between the monuments, considered to belong to the past, and the people and the social and cultural processes of the present" (2010: 171).

Still another pressing issue in heritage conservation today concerns its perceived elitism, as formulated by Fitch in 1982:

> Historic preservation [heritage conservation in Europe] has been traditionally characterized as «elitist», but this viewpoint is being modified as wider sections of the population begin to understand the cultural values of their own habitat and to demand a role in the formulation of plans for its preservation. This development should by no means be regarded as undesirable. To the contrary, it presents an unparalleled opportunity to correct some of the sense of alienation which is so characteristic of modern society. It affords the opportunity for the citizens to regain a sense of identity with their own origins of which they have often been robbed by the sheer process of urbanization. (J.M.Fitch, quoted in Lattig 2012: 5)

Even though the participation of stakeholders and the acknowledgment of the specificity of contexts are increasingly fostered, work is still needed regarding the recognition and inclusion of both values and the subjects who bestow them in the conservation of heritage objects – "Because values are not genetically previewed, but created, they need to be enounced, made explicit, justified and they can be proposed, refused, transformed – not imposed." (Meneses 2009: 39)

It is therefore unsurprising to read that "As a field, we need to be more rigorous, analytical, and transparent with our decisions" (Mason 2004: 70). Conservation today should work towards constructing a coherent body of work that allows it to adequately respond within three main spheres of challenges: (1) questions related to the physical condition of heritage objects, for obvious reasons, and undoubtedly the sphere where more research effort has been put in with practical application effects so far; (2) management issues, and namely questions dealing with resource allocation, professional training, regulations and policies, etc; and (3) significance and values attached to the objects, particularly the definition of the *why* and of the *for whom* a given object is conserved (Avrami et al. 2000).

The current chapter is devoted to the grounds of contemporary perspectives on heritage conservation, followed by some of the ethical implications these perspectives bring about; it tries to answer the two following questions: (1) what is at stake when conserving a heritage object today? and (2) what guidelines and restrictions currently make good conservation practice? This exposé does not intend to be thoroughly exhaustive (that would call for a dissertation in its own right), but simply to provide a framework for the ensuing research.

## 2.1. Frame of reference

*If, for the rest, it be asked us to specify what kind of amount of art, style, or other interest in a building makes it worth protecting, we answer, anything which can be looked on as artistic, picturesque, historical, antique, or substantial: any work, in short, over which educated, artistic people would think it worth while to argue at all.*

William Morris (1877)

Any process of conserving a given object should bear in mind the purpose of doing so, so that the goals of said conservation process may be clearly established from the outset.

An object is selected as heritage, and thus chosen for conservation, when a person or a group of people assign it with value(s) they wish to keep and/or share with others, in the present and/or in the future; logically, it follows that the primary aim of conserving an object is to preserve or enhance its values.

This essential aim underlies every action ever directed to the preservation of any object but, throughout the centuries, opinions differed not only on which value(s) should be assigned to which objects, but also on which value(s) took precedence and on which actions would best preserve or enhance those value(s). These debates derive from the fact that

> Value is a social construct dependent on social relationships [and] is bound to change through time and between cultures. […] It is an extrinsic property that cannot be directly detected by the senses, it does not exist without a social context. (Ashley-Smith 1999: 81-82)

The first author to clearly state these dilemmas, thus becoming "the author of the first systematic theory of conservation" (Jokilehto 1986: 378), was Alois Riegl (1858-1905). Riegl tried to define what was implied by the use of the word 'monument' ('heritage object' in this dissertation – see Glossary). The Austrian art historian considered that the 'historical and artistic' values, officially used in his time to characterize monuments, could lead to misunderstandings, because of the shifts in the perception of 'artistic value' over time. Instead, Riegl prefers to use the concept of commemorative value[1], which all heritage objects are said to be imbued with, and which was the key-defining concept behind the use of the word 'monument'; it differed from present-day values, which may be found in heritage objects but can also be applied to contemporary non-heritage objects. Still according to Riegl, 'monuments' can be deliberate or unintentional, depending precisely on whether the recognition of their commemorative value depends on prospective or retrospective cultural memory, respectively.

Riegl's genius and importance are highlighted by Choay in her introduction to the French translation of *Der moderne Denkmalkultus: sein Wesen und seine Entstehung* ("The Modern Cult of Monuments: Its Essence and Its Development"):

> for the first time in the history of the notion of historical monument and of its applications, Riegl distances himself. […] In the favour of such distance, he is able, firstly, to undertake the inventory of non-explicit values underlying the concept of historical monument. Suddenly, the latter loses its pseudo-transparency of objective given. It becomes the opaque support of historical values that are transitive and contradictory, of issues that are complex and conflicting. In this fashion, Riegl demonstrates that, in terms of both theory and practice, the destruction/conservation dilemma cannot be absolutely determined, that the what and the how of conservation never comprise *a single* solution – just and true – but *multiple* alternative solutions of relative pertinence. (Choay 1984: 16-17, italics by the author)

In the early 20th century, Riegl had already recognized that conservation objects are considered as such because of the values we – subjects – attach to them. Though dismissed for some time in the name of (positivist) objectivity, this subjectivism inherent to conservation decision making is nowadays widely acknowledged. Hence, in the light of the new paradigms proposed by contemporary conservation thinking, subjectivism, and intersubjectivity[2], is growingly being recognized as not only unavoidable, but also desirable in conservation decision making. These new paradigms acknowledge the ultimate role of decision makers and suggest that the focus on the (conservation) objects (and the objectivism proposed by classical conservation theories) be withdrawn and transferred to the subjects affected by these decisions – the users for whom the objects have values, functions or meanings (Muñoz-Viñas 2005).

Evidently, this intersubjectivism has nothing to do with the subjectivity that this research aims at dimming when conservation decisions are being considered. Quite the opposite, the fact that merely object-related information is insufficient for decision making is acknowledged and the relevance of subject-related aspects is highlighted, including the need for understanding the role and importance of the heritage object within relevant social groups and of the stakeholder

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[1] A more literal translation of the term used by Riegl, *Erinnerungswert*, would be 'remembrance value', which, in my opinion, would convey its meaning more precisely. However, 'commemorative value' was the term chosen by the translators of both of the English sources consulted (1982, 1996) and also by Jukka Jokilehto in his dissertation "A History of Architectural Conservation" (1986), and was thus preferred.

[2] Noun formed from the adjective 'Intersubjective', defined as "involving or occurring between separate conscious minds; accessible to or capable of being established for two or more subjects (in http://www.merriam-webster.com/dictionary/intersubjective, consulted November 24, 2011).

involvement in its conservation. Stating the values of an object and choosing which ones are to be conserved provides a framework for the intervention and acknowledges the intersubjectivity of the choices made. Of course this implies a clearer responsibility for decision makers, but it also supplies them with a tool for trading and negotiating the values at stake and those that are to be preserved.

Stewardship institutions today evoke a multitude of values when assessing the importance of a heritage object – or, better said, its *significance*. Many new values are added to the more traditional historical and aesthetical ones and reflect the ever-changing perspectives with which societies regard their culture and history, and objects as tokens of these: referenced below are concepts such as universality and communal values, which highlight the social importance of heritage objects nowadays, but whose influence over conservation decisions is yet to be more clearly defined. Also included in this section are the concepts of authenticity and integrity, which gained an extreme relevance throughout the 20th century and are at the centre of many conservation-related debates, and as such found their way here.

### 2.1.1. Values & Significance

*a thousand different sentiments, excited by the same object, are all right; because no sentiment represents what is really in the object… Beauty is no quality in things themselves: it exists merely in the mind which contemplates them; and each mind perceives a different beauty.*

David Hume in *Of the Standard of Taste*, 1777 (quoted in Mason 2006)

Significance is used throughout this document as a descriptor of the overall values of a heritage object. It should be highlighted, however, that significance per se is not an immediately applicable concept when planning heritage interventions: "It is the types of value that an object has that affect treatment decisions" (Appelbaum 2010: 115).

As mentioned earlier, the notion of value has been increasingly called upon in the context of heritage conservation. In fact, even if not specifically stated, heritage objects, by definition, possess an array of values which, among other things, justifies their preservation. Given the diversity of objects that societies believe to merit a conservation effort, including works of fine and applied arts, ethnographic and archaeological objects, buildings and musical instruments, among others, it is reasonable to say that

> these objects do not answer to the same function, they are not the result of the same intentionality. Their status varies: the values we ascribe them vary as well, since the fact that we conserve them endows them with a teleological dimension. We conserve and we restore because we found them to have a particular interest, and that is what we contribute, consciously or unconsciously, to put in evidence. (Verbeeck-Boutin 2009)

The underlined fragment emphasizes that any decision affecting a conservation object will necessarily reflect the decision-maker(s)'s value system, even if they are unaware of it themselves. The reasoning that Darvill applied to archaeologists is extendable to other heritage experts, who are "both participants in the application of value systems through being members of society, and generators of more widely adopted values because they are experts in their field" (1994: 40). The precise stating of those values is, therefore, crucial for our – and our successors' – contextualizing and understanding of conservation options – as Verbeeck-Boutin puts it, "the understanding of the subjectivity of values is our best chance of achieving objectivity" (2009: par.13).

The relative importance of values and their role in conservation decisions had been noted, prior to Riegl, by Camillo Boito: the Italian scholar participated in several notable restorations in a context torn by the Manichaeism of the positions of Ruskin and Viollet-le-Duc, and had the remarkably perceptive insight of "denouncing the fallacy of this alternative and of having, fifteen years before Riegl, placed the restoration of monuments under the sign of relativity and questioning." (Choay 2000b: 13)

As Choay notes, even if his writings lack the clarity and elegance of the Austrian author, Boito had the practical experience that Riegl missed, and his considerations on conservation are the fruit of auto-analysis rather than abstract thinking; this causes Boito to take the relativism in conservation farther than Riegl:

> For him [Boito], the complexity of the intervention on historical monuments renders the problem insoluble. As Riegl, Boito shows that the conservator must «make choices». But these choices are not separable from a «cruel uncertainty», they constrain the practitioner to constantly question himself, to «review his opinions and retract himself», to never be able to conciliate the absolute respect towards the past work and the necessary creative urge of the architect, in brief, to admit the impossibility of the empirical synthesis to which Riegl's dialectic leads (Choay 2000b: 17, with quotations from Camillo Boito).

Boito's practical experience allowed him to make a few proposals to help resolving some of the conflicts encountered in architectural conservation, e.g. the advocating of making additions discernible to the viewer, which is consecrated in the Venice Charter and still practiced today.

After Boito and Riegl, many decades passed where conservation was dominated by an "empirical-positivist philosophy[:] in this approach, significance is objectively determined, because values are considered qualities inherent in a site. Therefore, identifying and interpreting values depend only on the state and advance of knowledge, and on the precision of the observation instruments" (Zancheti et al. 2009: 50). In the past few decades, however, and notably after the first edition of the Burra Charter (in 1979), emphasis gradually began to shift towards the acknowledgement of the socio-cultural character of significance, i.e., towards a subject-based approach to heritage conservation. This shift is patent in the noteworthy efforts that many authors (and institutions) have increasingly dedicated the study of heritage values, trying to assess these both in absolute and relative terms. A survey of these efforts is described in the subsections below with a double purpose: (i) to more clearly ascertain the (pivotal) role of significance in the conservation frame of reference; and (ii) to provide a summary outline of the several systems and tools available to conservation professionals for tackling the values of heritage objects.

#### Value assessment systems

*Conservators-restorers will benefit from accommodating in their field some "conceptual tools" issued from philosophy or from aesthetics, since it is in the core of their actual practice that questions are born for which they have, sometimes alone, sometimes in teams, to find answers and solutions. The intellectualization of the profession, as it is emerging in higher education programs implemented in recent decades, calls for an autonomy that is no longer the artist's, the craftsman's, the technician's, but that of whom […] is required to "evaluate": that is to say, literally, to express the values connected to the objects and works. The conservator is therefore an unconscious axiologist.*

M. Verbeeck-Boutin (2009)

Evidently, the notion of value was always more or less close to that of a heritage object, but it gained new dimensions with the thinking of Alois Riegl; since Riegl, several authors have reasoned on heritage values and proposed (value) assessment systems to support conservation analysis and/or decision making. Although already mentioned by Lemaire in 1938 (Jokilehto 1986), value-led conservation gained a new momentum with the Burra Charter, which simply proposes the analysis of the set of values attached to the conservation object and, from there, reaching a consensus, between the stakeholders involved, concerning which values are to be preserved and which ones may eventually have to be disregarded. Besides providing some technical tools to assist the evaluation process, a values-based approach (see Section 2.1.5) acknowledges the importance of negotiation and of intersubjectivity in conservation decision making; on the other hand, "the idea of value is applicable to a wide range of conservation ethical issues" (Muñoz-Viñas 2005: 179).

The main features of some of these value assessment systems are described in Table 2.1, but a more detailed account of the value typologies proposed by the different authors mentioned here may be found in Appendix A. A comparative analysis of these value-assessment systems, or typologies, allows concluding that, "In most instances, [the authors] describe the same pie, but slice it in subtly different ways" (Mason 2002: 10).

**Table 2.1:** Heritage value assessment systems.

| For | Author(*) | Context/scope of application | Proposed assessment tool(s) | Remarks |
|---|---|---|---|---|
| Unspecified objects (movable and immovable) | Riegl [1903] (1982, 1984, 1996) | Conceptual support to conservation-restoration | Value description.<br>Analyses value conflicts and the impact of conservation actions. | First author to theorize (values regarding) conservation. |
| | Lipe (1984) | 'Cultural resources' (movable or immovable) | Conceptual support | Emphasis on ethical issues. |
| | Michalski (1992) | Understanding issues and responsibilities involved in conservation decisions. | Intellectual framework for conservation decision making. | Includes values in the 'conservation space', namely on the way original material, restored areas and defects are perceived. Endorsed by Muñoz-Viñas (2005). |
| | Mason (2002) | Site management in particular.<br>Informing conservation decisions. | - Quantitative methods (for economic values): revealed- and stated-preference methods.<br>- Quantitative methods (for cultural values): expert analysis; etnography methods; mapping; primary (archival) and secondary literature research; historical narratives; descriptive statistics. | Comprehensive review of value-assessment tools and methodologies.<br>Based on a clear distinction of sociocultural and economic approaches. |
| | Meneses (2009) | Understanding the social mechanisms that drive heritage actors. | Value description | – |
| Immovable heritage | Boito [1893] (2000) | Determining the type of conservation intervention | Value description | – |
| | Lemaire [1934] (1986) | Conceptual support to conservation-restoration | Value description | (I had no access to primary source; analysis is based on Jokilehto (1986)) |
| | ICOMOS Australia [1979] (2013a, 2013b) | Site management, including conservation. | The 'Burra Charter Process'; includes guidelines for significance assessment using value descriptions and a checklist of questions. | Widespread use across Australia and other Anglo-Saxon countries. |
| | Kerr [1982] (2013) | Site management, including conservation interventions. | 'Conservation Plan Methodology': "designed as a guide to the conservation of places that derive from a European cultural tradition" (2013: 2). Includes detailed value descriptions and examples of application | Widespread use across Australia and other Anglo-Saxon countries; endorsed by ICOMOS Australia. |
| | Feilden (1993; 2003) | Conceptual support to conservation-restoration decision making | Value description | Extensive value listing. |
| | Mohr & Schmidt | Valuation as a policy tool: "as an ingredient in a public | Direct methods:<br>- CVM (e.g. WTP or WTA) | Economic (chiefly monetary) valuation: expert |

| For | Author(*) | Context/scope of application | Proposed assessment tool(s) | Remarks |
|---|---|---|---|---|
| | (1997) | cost-benefit analysis" for rational decision making in "societal investment projects." (1997: 335) | Indirect methods:<br>- Hedonic market method;<br>- Travel-cost model;<br>- Averting behaviour approach. | opinion counts as much as non-expert opinion. |
| | English Heritage (2008) | The understanding of significance stands at the core of the definition and implementation of heritage management strategies, including those pertaining to specific conservation interventions, maintenance or repair. | Value description | Presumably used extensively in the management of designated objects/sites in England, where, at the very least, it informs the management of WHS. |
| | Van Balen (2008) | "Understanding the complexity and sometimes even opposing character of heritage values" and "evaluat[ing] possible preservation strategies" (2008, p.45) | 'Nara Grid': a table confronting heritage 'Aspects' and 'Dimensions' that, once filled , should inform on the object significance. Instructions on how to fill the 'Grid' via case-study examples. | Assumes 'significance' and 'authenticity' to be synonyms.<br>Adapted to historical mortars by Veiga et al. (2011) |
| **archaeological heritage** | Darvill (1994) | Archaelogical objects/sites | Value description | Attempts a sociological approach, as opposed to an economic one. |
| | Carver [1996] (2013) | Archaeological sites (actual or potential).<br>Management of archaeological resources (known and unknown) at government level. | Value description | Advocates for prioritizing the unknown instead of the known resources;<br>Argues for the prevalence of research value over 'monumental value' in the management of archaeological resources. |
| | Deeben et al. (1999) | Management of archaeological sites at government level. | Value description and rating system.<br>Proposes preservation thresholds (below which preservation is unnecessary) | Advocates for a stronger articulation between the academia and site management. |
| **movable heritage** | Ashley-Smith (1999) | Risk assessment as an object conservation tool | - For valorization: value description;<br>- For valuation: CVM (e.g. WTP or WTA) (see below) | Includes a risk perspective on the impact of conservation treatments. |
| | Brooks & Eastop (2006) | Textile cleaning | 'Paradigm' (value) description. | Values are deduced from conservation choices. |
| | Appelbaum [2007] (2010) | Decision making in conservation-restoration interventions | 'Conservation treatment methodology' is a guide to the whole intervention process, including value assessments. The author provides value descriptions and additionally recommends literature and expert consult. | Includes examples of application and the analysis of the impact of conservation upon values. |
| | Russel & Winkworth (2009) | "single items, collections and cross-collection projects" (2009: 1) | 'Significance 2.0' is a guidebook that operationalizes significance | Takes the Burra Charter precepts and applies them to movable heritage and |

| For | Author(*) | Context/scope of application | Proposed assessment tool(s) | Remarks |
|---|---|---|---|---|
| | | Collection management, including: "in collection policies, for acquisitions and deaccessioning, in conservation, planning, promotion, advocacy, education, online access, and in innovative collaborative projects" (2009: 1) | assessment via checklists of questions and application examples. | collections. Operative process. Prepared by the Collections Council of Australia. |

(*) Where they do not coincide, original publication dates are given in square brackets, whereas their respective bibliographic references are given in parentheses.

Most authors provide more or less detailed value descriptions that may be used by planners as a starting point; a few documents, and notably the Australian sources (ICOMOS Australia 2013a; Kerr 2013; Russell & Winkworth 2009) and Appelbaum (2010), additionally provide checklists and/or examples of application. When a significance assessment is necessary, the person(s) responsible may either borrow one of these systems or adapt them, but it is nevertheless important to outline the chosen system by providing a reference and/or a summary description of the considered values, as well as the grounds for the assessment.
In the analysed value-assessment systems, the most commonly referenced heritage values are those related to aesthetics/art, scientific (or evidential); and symbolic or spiritual, as described in Figure 2.1.

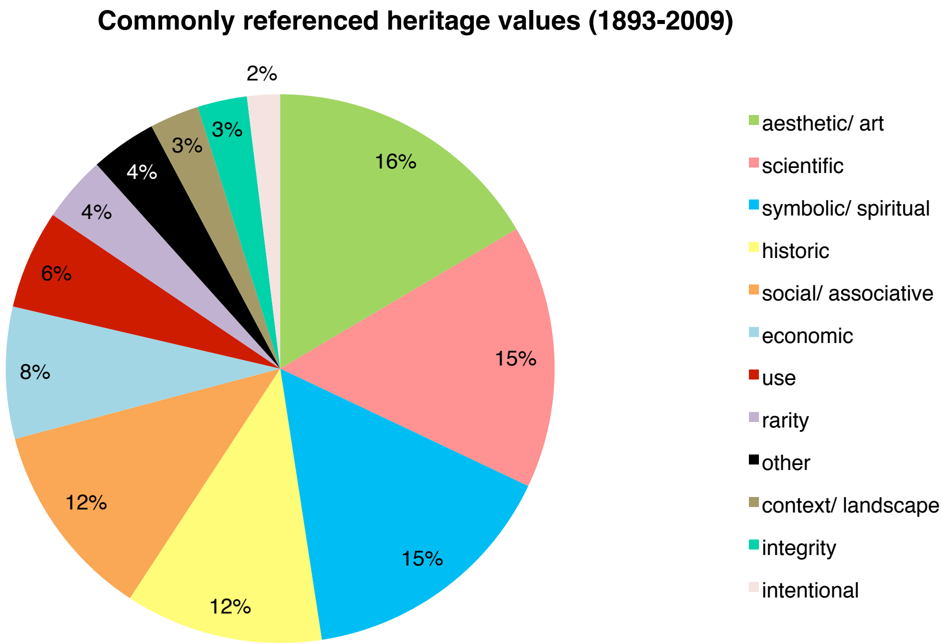


**Figure 2.1:** Heritage values referenced in the surveyed literature; aesthetic, scientific and symbolic values make up for almost half of the found value-system references.

Notably, Cesare Brandi, perhaps the most inescapable reference in 20th century conservation theory, does not acknowledge the importance of values other than historical or aesthetical; while mentionning 'use', Brandi defends that any instrumental value that an object may possess is to be overshadowed the instant of its recognition as a work of art:

> For works of art, even if there are some that structurally possess a functional purpose (such as architecture and, in general, objects of the so-called applied arts), the

> reestablishment of the functional properties will ultimately represent only a secondary or accompanying aspect of the restoration, never the primary or fundamental aspect that respects a work of art as a work of art. (Brandi 1996: 230)

In his widespread definition, Brandi defines restoration as "the methodological moment in which the work of art is appreciated in its material form and in its historical and aesthetic duality, with a view to transmitting it to the future" (1996: 231). Thus, only the historical and, especially, aesthetical angles are deemed crucial for the conservation process, an approach that the pie chart above would clearly demonstrate as incomplete at best. Moreover, Brandi does not acknowledge the antagonizing implications of this historical-aethetical duality, nor does he offer advice on dealing with them:

> the *Teoria* advises that conservation should not abolish history, but also that conservation should make a part of the history of the artwork disappear [if pertinent to recover the object's 'potential unity']; it urges that decisions on the removal or preservation of patina must not be based on taste or opinion, but at the same time states that aesthetic judgement must guide these decisions; it mandates both that aesthetic value should always prevail and that aesthetic value should not always prevail. […] in these and other regards, the *Teoria* avails a given view and its opposite. (Muñoz-Viñas 2015b: par.32, italics in the original source)

Inconsistencies aside, "Brandi's markedly *aesthetocentric* theory [is] incapable of explaining or guiding conservation as it is currently understood" (Muñoz-Viñas 2015b, par.42, italics in the original source). The obsolescence of Brandi's theory is accrued by his centering of the analysis in the materiality of the object: "Brandi takes a step backwards relatively to Riegl, in the sense where he presents, in an idealistic viewpoint, values as objective and inherent to the work [of art]" (Verbeeck-Boutin 2009: par.6), thus failing to acknowledge the determinant role of its stakeholders. It could furthermore be argued that Brandi's emphasis on the "transmitting [the 'work of art'] to the future" also somewhat elides present stakeholder's needs and aspirations.

When devising a significance assessment system today, planners should be aware not only of the value diversity facing them, but also of the stakeholders and communities holding those values. Although object typology (unspecified, immovable, archaeological, movable) may influence the choice of an assessment system from the ones given above, it is worth noting that an analysis of value references by author, as displayed in Figure 2.2, shows no clear relationship between the typology of the object and its ascribable values.

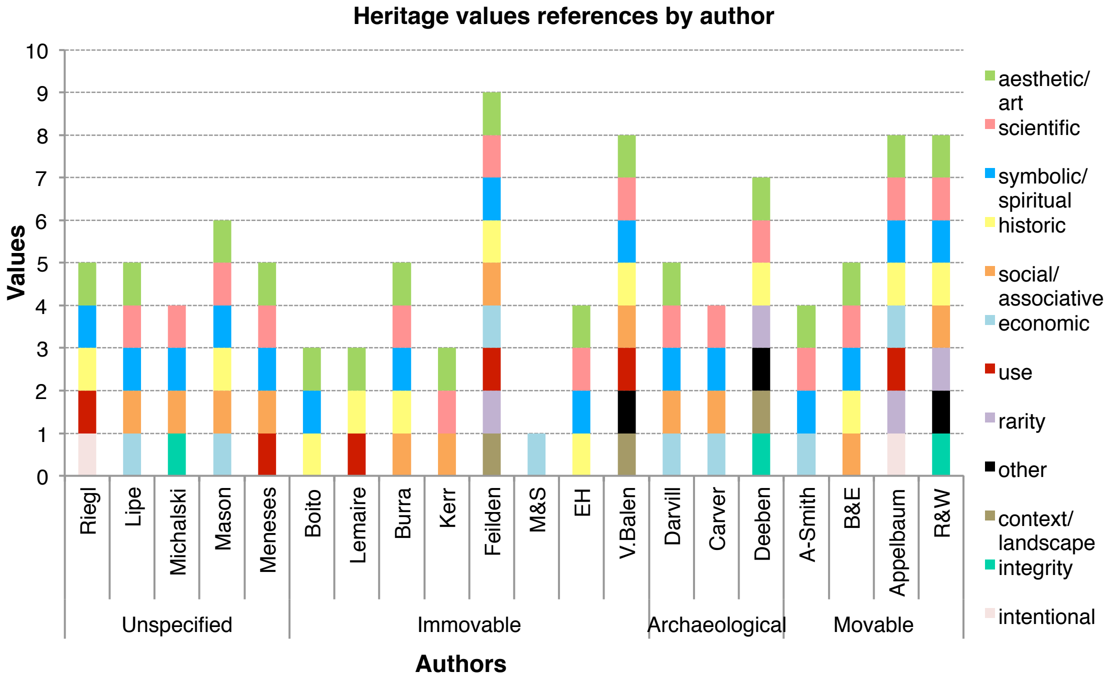


**Figure 2.2:** Values referenced by author. There is not a clear shift in value references depending on the type of heritage object.

Remarkably, almost all authors reference aesthetic values: these are not a distinctive heritage feature (Appelbaum 2010; Riegl 1984), but they are clearly of paramount importance in heritage value assessments; almost as important are symbolic/spiritual values and scientific values. The prominence of scientific values, which are systematically referenced by all the consulted sources from the second half of the 20th century onwards[3], may perhaps explain the somewhat unexpectedly lower value of historical value references: the documental character of objects may be partly conceptualized as scientific value, even if some authors reference both; likewise, links to historic personalities or events may be viewed from a social or even symbolic perspective. As remarked in the Burra Charter Practice Note on Cultural Significance, many values possess an historical dimension, and it could thus be said that historical value "often underlies other values" (ICOMOS Australia 2013a: 3).

Generally, the analysed value systems seem to try and encompass two broad categories of values: those that are chiefly personal (e.g. aesthetical, symbolic/spiritual), i.e., that result from an individual perception; and those of a more societal[4] character (e.g. historical, scientific, social/associative), which stem from a shared understanding of the object. Given their scale, built heritage objects (including archaeological sites) will hold values in both categories to a more or less wide community at any given moment in time.

### *Levels of significance*

*A museum curator answered "every day", when asked how often he dealt with value assessment issues*

T. Luger (2011)

[3] With the exception of Mohr & Schmidt (1996), who were uniquely concerned with measuring the economic values of heritage sites.

[4] Appelbaum suggested that values may be considered either personal or cultural: "Personal values are those held by owners and perhaps their families. Cultural values are those held by a broad group of people or society at large. Most objects that conservators treat have both kinds of value, so the distinction has no affect on their treatment." (2010: 89). In here, for the sake of clarity, the term 'societal' was preferred to 'cultural'.

There have been some more or less recent attempts to develop relative measures of significance; it is by no means an easy endeavour, and attemps are still currently underway (Michalski 2008; Muñoz-Viñas 2015a). One possible direction is to perform economic valuations, a field to which much research has been dedicated in the past decades, but whose methods seem to be unable to fully encompass the richness of cultural values, likely due to their originating from a different analytical system (see next section). On the other hand, it must be underlined that value assessments are needed, or performed, in specific contexts, with specific objectives, to meet specific aims; and economic valuations are not necessarily useful or usable in every intended application requiring a value assessment.

An indirect way of understanding the relative values that a given object has for a given community is to analyse said community's legal protection mechanisms, and namely heritage designation rankings. Of course, these imply that the community in question (1) cares for such measures to be implemented and (2) has influence over legislative decisions, and therefore it could be argued that national (or even municipal) designation systems blur the heterogeneity of values and aspirations bestowed upon heritage objects by specific communities.

A few examples of national designation systems for immovable heritage are presented in Appendix B; typically, three to four categories/levels of importance exist, with protection increasing for the most valuable objects, allowing to categorize these in terms of significance. Nevertheless, it is worth remembering that these systems were not explicitly designed to make significance comparisons; at least in principle, they were created with a purpose plausibly not too dissimilar of the one that presides over the Portuguese system, which aims at protecting heritage as a "primary instrument of realization of human dignity […], a means at the service of culture democratization and the mainstay of national independence and identity", thus "ensuring the transmission of a national heritage whose continuity and enrichment will unite the generations in a unique civilizational route" (*Lei 107/2001 - Lei de Bases do Património Cultural* 2001: art.3).

Kerr, one of the authors of the Burra Charter and the proponent of a Conservation Plan Methodology (2013) that is widely used across Anglo-Saxon countries in the implementing of values-based conservation (see below), advises against the use of levels of significance such as 'local', 'regional' or 'national', "as they now come loaded with meanings irrelevant to the assessment process" (2013: 20). The Australian author suggests for alternative levels to be defined, using "Neutral terms such as 'high' and 'low'", or "exceptional", "considerable", "some" and "little" significance (2013: 19-20). While official designations "should be noted", they will likely not possess the necessary depth for a significance assessment made in a conservation context, and therefore "should not be given undue weight in the assessment process" (Kerr 2013: 20). Interestingly, the Heritage Council of New South Wales recommends Kerr's levels of significance for the assessment of "individual elements of a place" (Lavelle 2009: 4), also connecting them with the official designation system. Quoting from a preceding manual, it remarks that "Different components of a place may make a different relative contribution to its heritage value. Loss of integrity or condition may diminish significance. In some cases it may be useful to specify the relative contribution of an item or its components." (Lavelle 2009: 4)

An example of a value-ranking system developed with a specific strategic conservation purposes is the Deltaplan, an initiative promoted by the Dutch government between 1990 and 2000, following the report of a critical backlog in the conservation of archival, library and museum collections (De Bruin 2004). This plan allocated funds for conservation needs providing a prioritizing of those needs was performed at national level, requiring not only a survey of said conservation needs, including storage and display conditions, but also a categorization of the objects and collections according to their value, i.e., an appraisal of their relative significance. For this, a "system of cultural/historical standards that clearly expresse[d] the quality of [an object and/or] collection was drawn up by museum professionals" (Kirby Talley Jr. 1999: 13); the system was "sufficiently abstract (while at the same time unambiguous)" (Kirby Talley Jr. 1999: 13) for application to different (movable) item typologies (textiles, paintings, archival documents, etc). Four basic categories were devised, from A (more valuable) to D ("not worthy to be kept in the collection" (Ashley-Smith 1999: 312)), as follows:

**Table 2.2:** Criteria for ascribing value categories within the Deltaplan

| Cat. | Criteria |
|---|---|
| A | "The object is compatible with the museum's purpose and is irreplaceable and indispensable to Dutch cultural values because of its 'symbolic value' […] of paramount importance to Dutch or international history, 'reference value' – the object is unique or prototypical; [or] 'link value' [of key importance to] an artist […], a branch of learning, school or style" (Luger 2011: 3) |
| B | "The object is compatible with the museum's purpose and is important to the museum on account of its 'presentation value' [in displays]; its [visitor] 'pulling power' […]; its 'genealogical value' […]; its 'ensemble value'; [or] its 'documentary value'" (Luger 2011: 3) |
| C | Objects that "are still important to the collection since they round it out or add significance to its overall context. They are, however, kept in long-term storage rather than placed on display" (Kirby Talley Jr. 1999: 14); |
| D | Object "is not compatible with the museum's purpose but has ended up in the collection by chance or on account of its curiosity value: items of this kind can be deacquisitioned." (Luger 2011: 3) |

In the implementing of their risk assessment for the preventive conservation of the collection, the Canadian Museum of Nature (CMN) borrowed the reasoning behind the Deltaplan to define a five-category system, ranging from 1 (most valuable) to 5 (least important), to group its objects. Institutional priorities could then be defined more precisely, since it was assumed that the primary responsibility of the museum was towards category 1 objects (Waller 1996). Similarly, the Significance 2.0 guidebook was adapted into a 5-level ranking for the prioritizing of interventions on textile objects (MacLeod & Car 2014).
In spite of its influence, the Deltaplan also received some critics, particularly in more recent years, pointing out (1) its simultaneous assessment of the importance at a national level and at the collection level, which do not necessarily coincide; (2) its pre-assumption that some values, namely those in category B (e.g. 'ensemble value'), are less important than others, i.e., those in category A (e.g. 'reference value'); (3) its greater emphasis on single objects than on collections, a perspective that was entirely reversed in recent years; and (4) the fact that it did not satisfactorily tackle the subjectivity of the assessments (Luger 2011). These shortcomings led the Dutch Cultural Agency (RCE) to develop new guidelines for the assessment of museum assets, informed by the Deltaplan experience, stakeholders, conservation professionals and other heritage experts, case-study applications, and also teachings from the Australian Significance 2.0 guidebook[5] (Luger 2011; RCE 2014). Levels of significance were removed, but the new guidelines still suggest that "a value ranking or grouping" may be advised to "determine how [to] deal with the various parts of the collection, such as loan policy, storage conditions and the degree of physical deterioration that is acceptable." (RCE 2014: 49); only now, assigning levels of significance became a task for the planner(s).

Specifically for immovable heritage, the Queensland Department of Environment and Heritage Protection (EHP) defined "threshold indicators" for heritage site managers to assess whether the sites they supervise belonged in a state listing or not: in a manual aiming at operationalizing the application of the Queensland Heritage Act 1992, EHP provides a checklist of "significance indicators" for historical, scientific, aesthetical, architectural and social values (alone or in combination) but, to be worthy of a state designation, objects/sites must additionally fulfil certain requirements (EHP 2013), as described in the table below.

**Table 2.3:** Queensland heritage office's 'threshold indicators' as requirements for state designations (adapted and with citations from (EHP 2013: Table 1))

[5] See entry for Russell & Winkworth (2009) in Appendix A for a definition of the basic precepts of this guidebook.

| **Criterion** (as per the Queensland Heritage Act 1992) | **Type of significance** | **State threshold indicators** |
|---|---|---|
| the place is important in demonstrating the evolution or pattern of Queensland's history | Historical Scientific | Regional importance • Earliness • Representativeness • Distinctiveness/ Exceptionality • Rarity |
| the place demonstrates rare, uncommon or endangered aspects of Queensland's cultural heritage | All aspects of significance | Intactness/Integrity • Distinctiveness • Exceptionality |
| the place has potential to yield information that will contribute to an understanding of Queensland's history | Historical Scientific | Earliness • Rarity • Extensiveness • Intactness |
| the place is important in demonstrating the principal characteristics [including ways of life, customs, land uses, building technologies, etc] of a particular class of cultural places | Architectural Historical | Intactness/Integrity • Earliness • Rarity/Uncommonness • Exceptionality |
| the place is important because of its aesthetic significance | Aesthetic Architectural | Intactness • Integrity • Degree of deterioration • Setting and location context • Demonstrated representation |
| the place is important in demonstrating a high degree of creative or technical achievement at a particular period | Aesthetic Architectural Other | Intactness/Integrity • Peer recognition/ award |
| the place has a strong or special association with a particular community or cultural group for social, cultural or spiritual reasons | Social | Length of association • Demonstrated extent and degree of community association • Significant former association |
| the place has a special association with the life or work of a particular person, group or organization of importance in Queensland's history | Historical | Importance of the person, group or organization in Queensland's history • Degree or extent of the association • Length of association • Influence of the association |

The reasoning behind this use of indicators is very similar to the one presiding to the Significance 2.0 guide (Russell & Winkworth 2009) and its 'comparative criteria'[6]. Thus, aspects such as rarity, intactness, provenance or condition become qualifiers of significance, and may assist in significance rankings or groupings, either of sites as a whole (relatively to other sites) or of elements within such sites.

### *The contribution of economics*

*To measure is to know: this is the motto of all economic investigations into the valuation of cultural heritage.*

A. Klamer and P.-W. Zuidhof (1998)

The increasingly more consistent involvement between economics and cultural heritage acknowledges the vast influence of the former in nowadays' globalized society, and aims at a better understanding of some of the social processes implicated by cultural heritage conservation, while additionally contributing to empower the social role of the conservation field.

One of the most significant contributions of economics to cultural heritage conservation concerns the measuring of values. Processes of decision making are always based on the assignment or definition of the values involved – even if they are not always clearly stated – and on the appraisal of the expected shifts in these values induced by the different possibilities one has to choose from. Decision making in cultural heritage is, as seen throughout this chapter, no exception, and thus the valuing process is a capital one in conservation:

[6] See respective entry in Appendix A for a description of these criteria.

> First, valuing processes underpin conservation and should even be seen as *part of* the conservation process. Decisions of *what* to conserve and *how* to conserve are made in the context of many different valuing systems […]. Second, the valuing process consists of two distinct but intertwined parts: *valuation* (the assessment of the existing value) and *valorization* (the addition of value). These are essential parts of the conservation process, and the distinction between them helps explain why economic values (which, in broad brush, are the result of valuation) are often seen as quite separate from cultural values (which result more from the process of valorization) (Mason 1998: 5-6, italics by the author).

This stance is corroborated by Klamer & Zuidhof: "valuation involves the assessment of values that people actually attach to heritage goods, whereas valorization is the (re)appraisal of the heritage goods by means of deliberations, pleas by art historians, debates in public media, and so forth" (1998: 31).

Cultural (heritage) values and economic values differ because they emanate from different systems[7]. On the one hand, cultural values represent "a set of values about the nature of the human condition that expresses fundamental beliefs about human identity and the place of mankind in the universe (whether the latter is defined in physical or metaphysical terms)" (Throsby 1995: 200). On the other hand, "The economic value of cultural heritage can be defined as the amount of welfare [both material and immaterial] that heritage generates for society" (Ruijgrok 2006: 206). In economic terms, the following values have been suggested as attributable to heritage objects (Mason 2002; Mohr & Schmidt 1997)[8]:

- <u>Use value</u>: measure of the consumption of heritage or heritage-related goods or services that are traded in the market and can therefore be expressed in terms of price.
- <u>Non-use values</u>: these are, by definition, values that are not tradable in markets, since they do not stem from actual consumption – "They can be classed as economic values because individuals would be willing to allocate resources (spend money) to acquire them and/or protect them" (2002: 13):
    - option value: describes the hypothetical satisfaction/utility withdrawn by an individual from the possibility future consumption of a given (heritage) good;
    - existence value: describes the satisfaction/utility withdrawn from knowing a given (heritage) good exists (even if its consumption is not intended);
    - bequest value: describes the satisfaction/utility of being able to bequeath the (heritage) good to future generations.

As descriptors, the values described above seem to fail in encompassing the full richness of what makes a heritage object valuable. The interest of these values, however, resides mostly in their helpfulness as instruments of economic analysis; for that purpose, they try to translate heritage values into categories that will allow for value measurement, generally in terms of utility or price.

In economics, the valuation tool *par excellence* is, of course, the market. However, especially for nonuse values, the public good[9] character of cultural heritage objects, as well as the occurrence of externalities[10], cause markets to fail when dealing with this kind of goods. These two features objectively prevent markets to provide cultural goods in an efficient manner;

[7] 'Systems' is meant here as "a structured interpretation of the relationships between variables that describe something" (Throsby 1995: 200). As a social science, Economics is of course not separable from Culture; however, as pointed out by Mason, "the economic-cultural distinction is widely shared and remains a very useful analytic convenience" (2002: 10), particularly on the topic of values, and is used here as such.

[8] See authors' entries in Appendix A for a more complete description of these economic values.

[9] In economic terms, a public good is a good displaying both non-rivalry and non-excludability, which mean, respectively, that its consumption by one given individual does not hinder its consumption by others and that no individual can be prevented from consuming it.

[10] An externality is a positive (benefit) or negative (cost) effect, issued from a good, that is not priced in the market, i.e., it does not incur in a market transaction.

besides, normative failure is also a possibility, which occurs whenever said goods are not provided in a way that satisfies people's expectations, i.e., in a way considered unjust, inappropriate or immoral[11]. These normative failures are social and cultural and therefore may change over time and across social groups (Klamer & Zuidhof 1998). Although market-based evaluation methods are still employed, market failure in many instances has led to the use of alternative tools to analyse the mechanisms through which cultural heritage goods are provided and allocated in society.

As highlighted earlier, both (cultural) value conflicts and scarcity of resources force choices to be made; the evaluation of possible uses for said resources is crucial for rational decision-making; economically speaking, this implies measuring costs and benefits. Thus, alternative economic tools for the valuing of heritage are now being increasingly used to try and provide more solid bases for decision making in conservation; these tools are all based in the economic principle of consumer sovereignty in trying to ascertain the utility actual or potential consumers withdraw from heritage goods, and include (Klamer & Zuidhof 1998; Nijkamp 1991; Riganti 2006; Riganti & Nijkamp 2005):

- **Social cost-benefit analysis (for determining use values)**
  1. <u>revealed preference willingness-to-pay (WTP)</u>: WTP studies may assess actual (revealed) or hypothetical (stated) behaviour; whenever possible, WTP analyses actual consumers' behaviour – revealed preferences –, for instance by assessing admission fees for the right to use a heritage good. Nevertheless, when no fees are charged (or chargeable), other forms of measuring revealed WTP study (1) consumers' averting behaviour, i.e., the circumstances leading to not using the good; (2) the price paid for complementary goods, using a weak complementarity approach and (3) the price paid for other goods, using hedonic pricing (for instance, comparing prices of similar objects with and without heritage value); (4) the travel and time costs to visit the object or site (travel cost method) (Tourkolias et al. 2015);
  2. <u>impact studies</u>: these measure the economic significance of a heritage good in terms of the income that it generates directly and indirectly. Albeit extremely popular in past decades, "their inability to account for opportunity costs and for the variety of values ascribed to heritage" (Mason 1998: 17) caused their popularity to diminish; nevertheless, recent research undertaken for supporting management policies in a Norwegian World Heritage town (Bowitz & Ibenholt 2009) seems to indicate that its results are still generally acknowledged.

- **Survey-based techniques (to determine non-use values)**
  1. <u>contingent valuation method (CVM)</u>: this method surveys a pertinent group of people's WTP for a (hypothetical) good in a (hypothetical) market or willingness-to-accept (WTA) the (hypothetical) ceasing of access to the good, i.e., the compensation amount people would demand for a (hypothetical) loss; CVM allows obtaining a WTP or a WTA via the analysis of stated (as opposed to revealed) preferences. Perhaps more simply, "Under this approach [CVM] an individual is confronted with a hypothetical situation different from the status quo and is then enticed to reveal the monetary value attributed to preventing or bringing about the new situation" (Mohr & Schmidt 1997: 340). This method has been applied to analyse and/or define funding priorities for conservation interventions, both coupled with cost-benefit analysis (Báez & Herrero 2012; Tuan & Navrud 2008) or not (Kuhfuss et al. 2016). There are, nevertheless, important shortcomings to CVM, such as its high dependence on survey design and the reliability of preferences stated for hypothetical situations (Epstein 2003); issues regarding the selection of people to survey or the fact that it does not allow differences between specific and general heritage goods to be distinguished, along with decision

[11] Merit goods, for example, are defined as commodities that are good but that will be underproduced if it depends on markets alone, because the consumer does not have enough information to realize the benefits of this good. On the other hand, if the market fails to provide the expected heritage protection for the future, then it is an issue related to (lack of) intergenerational equity.

anomalies (Bonini 2007), among others, may also prevent their use for other than qualitative conclusions. However, it is the only technique that acknowledges option, existence and bequest values: "Unfortunately, the non-market nature of many cultural resources makes the use of methods like CVM a regrettable necessity" (Noonan 2003: 172). Their use together with other methods, such as referenda, is sometimes advised.

2. conjoint analysis/choice experiments: survey-based technique where the respondents are required to choose between different commodities, each one featuring a set of attributes. Respondents have to trade-off between different attributes, and the analysis of these trade-offs allows for the preference elicitation regarding these attributes; one of the attributes generally being the price, conjoint analysis also estimates WTP through stated preferences. For instance, Riganti (2006) used this method in Syracuse (Italy) to assess tourists' and residents' preferences between quality of experience/life and a sustainable management of tourism. Albeit dealing with environmental sciences, Stevens et al. (2000) provide a summarized comparison of CVM and conjoint analysis that sheds some light into differences in the WTPs obtained by the two methods.
3. direct referenda: the referendum provides a combination of actual and hypothetical preference statement by asking "a constituency to vote on a public expenditure for the arts that they have indicated in the CV study to be worthwhile" (Klamer & Zuidhof 1998: 34); however, the influence of propaganda and limited information and participation, as well as its costs, may somewhat deter its generalized use.

- **Multicriteria analysis**

Multidimensional approaches to valuation rose from difficulties found in reliably assessing public investment projects, including heritage conservation ones, with resort to the traditional economic tools mentioned above, as it is extremely difficult to find a common denominator in which to render the multiple objectives (resulting in multiple welfare criteria) and social costs that are characteristically involved in such projects. Assessments of a given project or object based on these approaches integrate diverse information, both qualitative and quantitative, be it of social, economical, historical, cultural or environmental nature, among others; Mazzanti suggested that cultural heritage goods should be defined as "Multi-dimensional", "Multi-attribute" and "Multi-value" (2002: 540-541). Intended both as a policy planning and assessment instrument, multidimensional impact assessment builds decision matrixes that attempt to describe all the possible outcomes of alternative policies; departing from these multidimensional impact analyses, multiple criteria analysis develops policy evaluation models, trying to capture the (multidimensional) social benefits of heritage and analysing it with resort to multidimensional utility theory.

- **Benefit transfer**

Benefit transfer consists of transferring information from study sites/objects to policy sites/objects that lack their own specific data, with the purpose of ascribing valuation estimates to the latter. Despite the challenges posed by the heterogeneity of heritage objects, and hence of its valuation studies, as well as the methodological specificities of valuation studies (Tuan et al. 2009), new attention has been brought to these because of the high implementation costs of CVM. Besides requiring several departure assumptions, benefit transfer must meet diverse criteria; consequently it must be resorted to with caution and more research is still needed before it becomes an acceptably reliable valuation tool for the cultural heritage field. Riganti & Nijkamp (2005) reviewed the research on the method, pointing out some of its limitations and potential, with the goal of fostering discussion on its applicability.

Each method has its own advantages and shortcomings that make it more or less adequate to each specific case (Riganti & Nijkamp 2004). Still, none of the listed methods is considered to provide exact answers, and results seem to be somewhat dependent on the chosen valuation method, somewhat undermining their reliability (Riganti & Nijkamp 2005). These limitations notwithstanding, valuation studies may still prove helpful for decision making about allocating resources for conservation, namely by integrating their results in the cost-benefit analyses of conservation projects (Noonan 2003).

Despite their usefulness in the context of decision making, the tools ensuing from economics must be used with caution in a discipline such as conservation, avoiding over-mechanistic approaches that place too much emphasis on the economic values of cultural heritage rather than on social and cultural values. The use of merely economic reasoning for conservation, based on jobs, income or wealth generation may be counterproductive, with the risk of "economic arguments [being] articulated in a way that begins to atrophy the other [social and cultural] arguments for conservation" (Bluestone et al. 1998: 20).
Perhaps the greatest shortcoming found in the approach of economics to cultural heritage lies precisely in its limitations in converting aesthetic, symbolic and cultural values, among others, into (mere) economic values, normally measured in monetary units (Mason 1998). Also, cultural objects are not necessarily produced because of consumer demands; in most instances, they were created for other, varied, reasons, and are defined as heritage objects by art-historians, anthropologists and several other heritage stakeholders. As Throsby puts it,

> cultural value, for all its ephemeral, shifting, incoherent and even irrational properties, is likely to influence peoples' decision-making in regard to cultural goods and might therefore affect desirable patterns of resource allocation in this area in ways that cannot be fully captured by standard economic analysis. (2003: 202)

A final aspect should be highlighted concerning the influence of economics in the value of heritage. Though, as highlighted earlier, economics mostly directs its efforts towards valuation processes, it too may influence the valorization of a given object via, precisely, its valuation. In other words, shifts in the price of an object may cause shifts in the values ascribed to that object (e.g., realizing that a given object has a higher than expected market price may trigger interest for its history). Given that economics is a social science, the opposite is, evidently, also valid: the valorization process is what, in principle, economists will try to measure via valuation, and thus shifts in the values attached to an object will have an effect in the economic value of that object. Going further, some economists defend that the specific form of financing a heritage object – be it the market price, a government subsidy or a non-governmental organization (NGO) gift[12] – will affect its valorization (Klamer & Zuidhof 1998); what is certainly true is that the valorization process will have a large influence on heritage financing possibilities.

#### 2.1.2. Authenticity

*our successors will see us as no less naive and credulous than we see those who came before us. Each generation views authenticity in a new guise, reflecting its new needs for truth, new standards of evidence, and new faiths in the uses of heritage.*

D. Lowenthal (1999)

For the Venice Charter, according to Jokilehto, authenticity is built upon the diverse "historical stratifications" (Jokilehto 1988: 267) of each heritage object, and these must therefore be preserved. This perspective of authenticity, which specifically prevented the removal of any of the elements that materialized the historic layers of an artefact (allowed only under exceptional circumstances), made perfect sense within the modern Western approach to art and conservation[13] but its application proved inadequate in different civilization and tradition contexts.

[12] A gift is a good that is transferred without a clear or formal agreement upon a specific restitution, albeit, economically speaking, gift-giving relies on reciprocity.
[13] "While the western philosophical approach as regards conservation manifests itself in the preservation of the historic monument, the oriental one tries to use the monuments to preserve the very spirit they represent." (Vecco 2010: 324)

Intended as more inclusive of differing perspectives on heritage, the Nara Charter (1994) defines authenticity as "the essential qualifying factor concerning values" (1994: art.10), and so authenticity may be interpreted as a requisite, not only of the (heritage) object, but also, and especially, of all sources of information used to understand and value it. Authenticity is described in the Nara Charter as strictly linked to the credibility and truthfulness of information sources; these may be of the most diverse nature, adding to the understanding of the object – with information on aspects such as "form and design, materials and substance, use and function, traditions and techniques, location and setting, and spirit and feeling, and other internal and external factors" (UNESCO & ICOMOS 1994: art. 13) – in its multiple dimensions. As concisely put by Jokilehto, "Authenticity can be understood as a *condition* of the heritage resource, and can be defined in the artistic, historical and cultural dimensions of this resource. These dimensions can be seen in relation to the aesthetic, structural and functional form of the object or site, in relation to its material and technology, as well as in relation to its physical and socio-cultural context." (1994: 32)
Pillared on the importance of cultural diversity, the Nara Charter clearly states the impossibility of imposing rigid criteria for the assessment of values or authenticity; these assessments will always depend, first and foremost, on the specific cultural contexts that generated the heritage object and, also, on the ones that tend for it.

Clearly acknowledging the importance of Nara, the recent revision of the New Zealand Charter defines authenticity as "the credibility or truthfulness of the surviving evidence and knowledge of the **cultural heritage value** of a **place**. Relevant evidence includes form and design, substance and **fabric**, technology and craftsmanship, location and surroundings, context and **setting**, **use** and function, traditions, spiritual essence, and sense of place, and includes **tangible** and **intangible values**. Assessment of **authenticity** is based on identification and analysis of relevant evidence and knowledge, and respect for its cultural context." (ICOMOS New Zealand 2010: 9, boldface in the original text)
For Lipe, authenticity lies at the very core of the associative/symbolic value of a cultural resource:

> Physically, cultural resources participate in both the past and the present. Their authenticity is the basis for creating in the contemporary viewer the subjective knowledge that he has experienced a contact with the past that is direct and real, however incomplete that experience may be. (1984: 4)

Mason similarly states that

> the notion of authenticity in the heritage field […] presumes that some kind of historic value is represented by—inherent in—some truly old and thus authentic material (authentic in that it was witness to history and carries the authority of this witness). Thus, if one can prove authenticity of material, historical value is indelibly established. (2002: 14)

The same reasoning may easily be extended to other values, e.g. scientific, informational, symbolic, art and economic, to name a few. Other than a value in itself, authenticity should be considered as a <u>sine qua non condition of values</u>.

Authenticity may refer to tangible or intangible object features, and "These references can be understood to cover the aesthetic and historical aspects of the site, as well as its physical, social and historical context, including use and function" (Jokilehto 1999: 298). This broadness, however, may prevent a clear definition of what is to be considered authentic or not, particularly in the case of buildings and structures and, to prevent misunderstandings and/or misinterpretations, Jokilehto suggests that the "historicity of the heritage resource" (1999: 298) be the key-defining element when approaching authenticity from the perspective of contemporary conservation. The focus on material-related issues, however, is not necessary applicable to heritage contexts or objects relying in a different understanding of authenticity and, thus, of the cultural practice of heritage. ICOMOS Americas, in their Declaration of San Antonio, suggest for authenticity appraisals to be dependent on the dynamic or static character of the heritage asset:

- "Dynamic cultural sites, such as historic cities and landscapes, may be considered to be the product of many authors over a long period of time whose process of creation often continues today. This constant adaptation to human need can actively contribute to maintaining the continuum among the past, present and future life of our communities". In these cases, changes in the materiality (or fabric) of these assets, when "associated with maintaining the traditional patterns of communal use of the heritage site do not necessarily diminish its significance and may actually enhance it." (1996: sec. B.5)
- "Static cultural sites include those valued as the concluded work of a single author or group of authors and whose original or early message has not been transformed." These include assets imbued with deliberate commemorative value, artistic value, among others, and include archaeological assets, "whose active communal and social purpose have faded or even ceased." For these objects, authenticity relies especially in the materiality, and thus "the physical fabric requires the highest level of conservation in order to limit alterations to their character." (1996: sec. B.5)

In other words, the more dependent cultural significance becomes from interpretation, the higher the importance of material evidence and, namely, of the heritage asset fabric. What the San Antonio Declaration very insightfully remarks is that "interpretation is not inherently authentic, only honest and objective", and therefore "the intactness of the physical evidence in its entirety demands the most thorough documentation, protection and conservation so that objectivity of interpretation may respond to new information derived from that fabric." (1996: sec. B.5)

Recently, Wells (2010, n.d.) proposed for authenticity to be regarded as also depending on connotations other than traditional fabric-based ones; borrowing from research on authenticity applied to tourism, Wells suggests that values must be understood in relation to 'objective (fabric-based)', 'constructed' or 'phenomenological (experiential)' authenticity, as depicted in the table below.

**Table 2.4:** Heritage authenticity in relation to its values (after Wells 2010, n.d.)

| Authenticity | Definition | Associated values (*) |
|---|---|---|
| objective | Sought in "«original» building or landscape fabric or fabric that has witnessed the passage of events from an important period of significance, [which should] remain extant". It concerns objective values, which "are the domain of educated experts—either academics or professionals—who use their skills to define value based on their own discipline's standards; as a result the public may have difficulty in understanding the rationale behind these kinds of expert-value definitions." (n.d.: 4) | Historical<br>Informational<br>Artistic/design<br>Rarity |
| constructed | When "defined through the lens of ideas or meanings rather than physical fabric", "a heritage object that is deemed authentic achieves this state through culturally- or socially-approved ideas or meanings that can exist independently of physical reality" (2010: 7). Temples in Japan are an example of objects where this kind of authenticity is deemed more important: "what is preserved are the ideas embodied in their construction rather than the actual construction materials" , and "Preservation of fabric is a secondary concern." (2010: 7). | Symbolic<br>Technical<br>Educational<br>Recreational<br>Spiritual/religious<br>Use<br>Social capital/ identity<br>Cultural attachment |
| phenomenological | Phenomenology "seeks to uncover the subjective elements of personal experience the moment they occur before subsequent personal reflection reduces the richness of the experience." This authenticity thus "focuses on the individual's experience of being in and relating to the world" (2010: 8) | Age<br>Newness<br>Spatial<br>Attachment |

(*) The vast majority of these values is defined similarly to the ones listed in Appendix A.

Authenticity, therefore, may vary, and as such be interpreted, according with the kind of values that are attached to an object, but it will always represent a sine qua non condition, or a requisite, for those attributed values.

### 2.1.3. Integrity

The integrity of a heritage object typically refers to its state of completeness, i.e., it characterizes the degree to which the object is whole or unified, as opposed to divided, impaired or with elements removed. Integrity is a requirement for sites listed as World Heritage, and UNESCO defines it as "a measure of the wholeness and intactness of the natural and/or cultural heritage and its attributes" (UNESCO 2015: art.88). Implementing the World Heritage Convention, which is legally binding to the countries that ratified it, means periodically assessing and submitting statements of authenticity and integrity within the recommended reports.

It should be stressed that Western views on heritage integrity are very strongly connected to the fabric or, as Matero phrased it, the discipline of conservation has a "longstanding preoccupation with the physicality of things and places over their social and spiritual life" (2003: 4)[14]. The same author reminds us that "integrity can also be defined in other cultural traditions by non-tangible qualities such as process, spirit or attached history and stories in establishing the value and significance ascribed by any one group over time" (2003: 4).

Smars et al. nevertheless remarked that "The major weight given to integrity may fit with a growing tendency towards reducing objects to the iconic value of their image […] or towards seeing heritage solely as a means of economic development" (2012: 120). Jokilehto also points out the risks of approaching integrity from a material perspective alone: it "may stress the trend to reintegration, stylistic restoration, or reconstruction" (1999: 299); the author does however, acknowledge the value of the concept as an operative tool for establishing the relative importance of each element within the whole of the site, thus assisting in significance analysis. Analogously, several authors and heritage institutions (e.g., EHP 2013; ICOMOS Americas 1996; Russell & Winkworth 2009) opt to view integrity as an indicator or a qualifier of significance.

### 2.1.4. Universality

*At the same time that globalization has standardized certain lifestyle elements among many of the world's populations, it has also led to an increased awareness of the multiplicity of cultures worldwide and helped individual cultures recognize their own uniqueness. A better understanding of the culture and heritage of others raises one's consciousness and estimation of one's own culture.*

John H. Stubbs (2009)

Today, it appears that "there is a great deal of evidence to suggest that local-, place- and community-bound values (i.e., those not, by definition, universally valued) are a more important impulse behind conservation" (Avrami et al. 2000: 69). As pointed out earlier, "culture is a set

[14] Matero illustrates his use of the adjective 'longstanding' by transcribing an account, dating from 1896, given by an American ethnologist working in the Zuni pueblo, in western New Mexico: "I urged them [the Zuni] to join me in cleaning out the old church, repairing the rents in its walls and roof, and plastering once more its rain-streaked interior … I asked them if they did not care for their *missa k'yakwi* or mission-house. 'Yea, verily,' they replied, with fervor. 'It was the sacred place of our fathers, even more sacred than were the things taken away there from.' I asked if they would not then in the memory of those fathers, restore its beauty. 'Nay,' they replied, 'we could not, alas! for it was the *missa*-house of our fathers who are dead, and dead is the *missa*-house! May the fathers be made to live again by the adding of meat to their bones? How, then, may the *missa*-house be made alive again by the adding of mud to its walls? Not long afterward there was a furious night storm of wind and rain. On the following morning, great seams appeared in the northern walls of the old building. I … urged that since they would not repair the *missa*-house, it be torn down; for it might fall down some day and kill the women and children as they passed through the narrow alley it overshadowed … Again I was told that … it was the *missa*-house of their fathers! How, if they took it away, would the fathers know their own? It was well that the wind and rain wore it away, as time wasted away their fathers' bones …" (2003: 3-4, italics in the consulted source)

of processes, not a collection of things. Artifacts are not static embodiments of culture but are, rather, a medium through which identity, power and society are produced and reproduced" (Avrami et al. 2000: 6). This would mean a greater emphasis put on specific contexts as grounds for preserving certain objects, i.e., on the relativity, rather than on the universality, of the values of heritage objects.

On the other hand,

> with the acceleration of the pace of manufacture and discard, and of the rate at which our landscapes are being changed, […] we have become explicitly concerned with the loss of human continuity and contrast brought about by too rapid a change in our cultural environments, both build and natural. (Lipe 1984: 1)

In other words, and according to Jokilehto, in today's multicultural urban centres that progressively traded a connection to traditional values for individualism and efficiency, sacrificing diversity for mass production, "cultural properties can play an important role in providing physical references for the re-establishment of cultural memory and cultural identity" (1999: 298).

In fact, the concept of "rules of inheritance" was recognized as a cultural universal, meaning that the tendency to keep things from the past and pass them on to future generations is cross-cultural (Ashley-Smith 2009) or, as Lipe puts it, "as old as human culture" (1984: 1). Artefacts made with the specific purpose of remembrance or commemoration – monuments in the etymological sense – are also a cultural universal (Choay 1994).

So, it seems that there are some universal values about heritage objects that are inherent to them and that transcend specific socio-cultural constructs, in what they foster "shared human longings for love and beauty and cooperation [since] the need for access to one's culture, one's heritage, crosses all cultures and contributes to human flourishing and happiness in the Aristotelian sense" (Avrami et al. 2000: 7). Naturally, which kinds of things are kept will differ within each social group. Although there is some disagreement on the importance of specific social contexts, i.e. on the relativity or universality of some heritage values, both sides seem to agree on a dependency of time and place.

The universality of some heritage objects is a traditional assumption in conservation that "emphasizes the positive role of heritage in promoting unity and understanding" (Avrami et al. 2000: 69) and finds a most eminent application example in the UNESCO World Heritage Site (WHS) List. For a long time, this feature, thought to distinguish some selected few objects, was considered as a fundamental support for their conservation. The influence of this universality status is undeniable and plays into conservation decision making; for instance, in Hadrian's Wall, the preservation of the 'Outstanding Universal Value' (OUV) bestowed upon the site by two listings within the UNESCO convention became a key value in the planning strategy – as reinstated in the 2008-2014 management plan, "The protection and enhancement of this OUV forms the basis for the management of the WHS" (HWMPC 2008: 26). The UNESCO World Heritage Operational Guidelines (2015) are to be consulted for the management of WHS, a designation which is a strong tourism propeller. However, many voices have been raised against the World Heritage Convention for "universalizing Western concepts of heritage and the values inherent within that" (Smith 2006: 28) and failing to fully acknowledge other heritage practices.

Conservation is a social activity – Philippot called it "a cultural problem" (P.Philippot, quoted in Jokilehto 2007: 277) – and thus inherently subjective, evolving according to "cultural contexts, societal trends, political and economic forces" (Avrami et al. 2000: 7). Currently, this awareness of cultural relativism demands further investigation towards what should be the scope of application of the universality concept in conservation, and namely in the assessment of the cultural significance of each object.

### 2.1.5. The space of conservation

*After* [The Modern Cult of Monuments]*, everyone knows that the heritage world is in perpetual conflict: its apostles and its believers confront each other in an endless war, in the name of values that are equally legitimate and mutually exclusive.*

P. Leveau (2012)

Throughout his work, Riegl illustrates how values attached to cultural heritage may be, and indeed often are, conflicting. Heritage preservation decisions are entirely dependent on which values society attaches to each particular object, and, more importantly, on which values prevail; the following table tries to summarize this dependence, according to Riegl.

**Table 2.5:** Riegl's values versus intervention decisions.

<table>
<tr><th colspan="3">Commemorative Values</th><th colspan="4">Present-day Values</th></tr>
<tr><td rowspan="2">Historical</td><td rowspan="2">Age</td><td rowspan="2">Deliberate</td><td rowspan="2">Use</td><td rowspan="2">Newness</td><td colspan="2">Relative Art value</td></tr>
<tr><td>positive</td><td>negative</td></tr>
<tr><td>preservation of the status quo</td><td>non interference (except in the case of a catastrophe)</td><td>restoration</td><td>renovation or recovery (whenever user safety is an issue)</td><td>restoration to the original known condition</td><td>Conservation and/or restoration</td><td>destruction (or renovation with new additions)</td></tr>
<tr><td colspan="7">Regarding objects with stylistic additions</td></tr>
<tr><td>removal of additions and renovation aiming at stylistic originality</td><td>non interference</td><td>–</td><td>–</td><td>removal of additions and renovation towards stylistic unity</td><td colspan="2">removal or maintaining of additions depending on the more pleasing option for the contemporary artistic volition</td></tr>
</table>

It is clear, from Riegl's theory, that some values will be sacrificed in favour of others. But, as described above, he furthermore analyses possible strategies for each conflict: "he examines, in fact, the different alliances that may tie these values together and shows that victory will come to the value which succeeds to associate with others, thus increasing our interest for the [objects] instead of reducing it" (Leveau 2012: 22).

Similarly, Appelbaum drew attention to how conservation decisions regarding (movable) heritage objects will depend the dominating value, as described in the table below.

**Table 2.6:** Appelbaum's values versus treatment implications (with quotes from Appelbaum 2010)

| Dominating value | Treatment implications |
|---|---|
| Art | "art is a loosely constructed category" (2010: 92); to consider an object as 'art' will foster interest in its other values, including aesthetic, historical, age, newness, associative, research, etc; often applicable, "the primacy of the artist and the artist's personality" (2010: 91) will also impact the perception of the object and of what should be the outcome of a treatment. Therefore, conflicts among the different values must be sorted before decisions are made. |
| Aesthetic | Because it relies on individual perceptions, it may be outweighed by other values. Its prevalence in treatment choices should require a collective decision on the final appearance of the object, which should match a past existing state – "the aesthetic preferences of the conservator and custodian […] have no legitimate place in decision making" (2010: 94). |
| Historical | If the object is mainly valued as a material testimony of a past event or period – though not as a source of technical information (see research value) – then, it can be "emblematic or illustrative [...] and it is most valued […] in its state from the time in question" (2010: 96) and therefore "restoration to a known historic state is the expected treatment" (2010: 96), albeit there will be implications on |

| | |
|---|---|
| | authenticity. For "some iconic objects, […] restoration to compensate for deterioration or loss may be considered undesirable if it covers even a trace of the original" (2010: 96) and, in such cases "reconstruction using a replica or written or graphic description" (2010: 96) is advised. |
| Use | "Objects in use can often be protected by treatment, but may require a greater degree of intrusion than for objects on display. […] The replacement of original working parts with new ones may be a reasonable course of action when the historical or research value of the original parts is high" (2010: 100-101) |
| Research | "Many objects […] hold clues to their use that can be destroyed during treatment if the conservator is not aware of their significance. Conservators should keep current about the possibilities for information retrieval, particularly when dealing with rare or pristine objects, and information of this type should be sought during the characterization phase. Requirements for research on scientific collections may be more stringent than those for [other] cultural objects and absolutely vital to preserving any value at all." (2010: 103) |
| Educational | If the "object's educational value outweighs its historical value", then the object is "replaceable" (2010: 104). |
| Age | "Not every possible sign of age needs to be left in place in order for a viewer to feel comfortable that an «old» object looks its age and is, therefore, authentic. […] Knowledge of the ageing of materials should enable conservators to judge which signs of age are undesirable in aesthetic terms and unnecessary to preserve age value." (2010: 106) |
| Newness | The "desirability" of an object valued primarily for its newness aspect will rely "on its being in virtually pristine condition" (2010: 108). It is, nevertheless "both an aesthetic and psychological issue" and, in some objects, "the look of newness can be unsettling", especially in combination with signs of age left behind – reactions to such incongruities are "difficult to predict" (2010: 109). |
| Sentimental | This is, by definition, a personal value that stems from an individual's private experience and/or memories with the object and that will not, in principle, have any substantial influence in conservation decisions concerning objects featuring other, shared/societal values, although it may play a critical role in the conservation of privately owned objects. |
| Monetary | "High monetary values can bring scrutiny to treatment details that no one would notice otherwise", although, unless sale is anticipated, "In most cases […] market value does not prove to be a major factor in treatment decision-making" (2010: 111-112). |
| Associative | In objects that draw most of their value from associations with a famous person, this value will either be short-lived (if the person is forgotten) or be changed into historical value (if the person becomes a historical figure). |
| Commemorative | Restoration, analogously to Riegl. |
| Rarity | Rarity is a value 'intensifier' that "does not have a consistent or automatic influence on treatment decisions" (2010: 115). |

Thus, the perception of the values bestowed upon a given object is the main determinant factor when it comes to conservation decisions. But conservation decisions will also affect the way an object is valued, by introducing changes in the way it is perceived and represented – value and conservation have been said to share a symbiotic relationship (Taylor & Cassar 2008). Taylor and Cassar (2008) suggested potential effects on value caused by different conservation decisions:

**Table 2.7:** Potential effects on value caused by intervention decisions– by Taylor and Cassar (2008: 5)

| Seven degrees of intervention | Possible repercussions on value |
|---|---|
| Prevention of deterioration | Intended to reduce change but certain kinds of value may be [unintentionally] given priority, so values change at different rates. |
| Preservation of the existing state | Many values kept; utility and possibly aesthetic and information values slowly decrease. |

| | |
|---|---|
| Consolidation of the fabric | Utility increases but information decreases, e.g. DNA information. |
| Restoration | Utility and aesthetics may increase but information and material authenticity may decrease. |
| Rehabilitation | Contextual value increases, potential uses may decrease. |
| Reconstruction | Material authenticity decreases, information may increase. |
| Reproduction | Reproduction is different, since the original object is not necessarily irreversibly affected by this intervention. |

A special reference should be made to the impact of preventive conservation (or prevention of deterioration): because no direct handling is involved, preventive procedures (for instance, the construction of temporary protective shelters) are not generally considered as introducing immediate significant changes to the object, but the fact is that choices are made to decrease specific deterioration rates, thus changing the evolution of the materials and, therefore, eventually having an impact on the values these materials embody: "In practice, conservators are always 'writing' the history of the object as even a decision to do nothing at all constitutes an interpretation articulated through presentation and display" (Villers 2004: 6).

Ashley-Smith details the impacts of conservation treatments for particular dimensions of significance. The author distinguishes value categories[15], namely economic, informational, cultural, emotional, existence (1999: Table 6.1), from 'contributors to value', defined as "factors that might contribute to a single concept of value. […] They might contribute to a sense of loss if evidence of those factors was destroyed by decay or vandalism" (1999: 85) and amount to "• Age • Rarity • Material • Complexity • Quality • History • Identity • Information • Context • Potential • Condition" (1999: Table 6.2). Thus, possible risks of conservation treatments should be appraised on these factors, as follows:

**Table 2.8:** Possible repercussions of conservation treatments on the 'value contributors' of an object (after Ashley-Smith (1999))

| Value 'contributors' | Possible repercussions of conservation treatments |
|---|---|
| Age, identity, rarity & history | "The *appearance* of age may be affected temporarily by addition of material, or permanently by removal. *Evidence* of age, history and identity may be permanently lost by removal or rearrangement of material. This evidence has the potential to change value, but if there is already other convincing evidence it may not be that important if the information intrinsic to the object is lost." (1999: 288) |
| Complexity & quality | "Complexity and the appearance of quality could be improved by treatment, usually by the removal of obscuring details on the surface of the object. Similarly there is a possibility that treatment will decrease complexity by hiding or removing detail." (1999: 288) |
| Information | "hidden information [i.e. not visible and eventually requiring more or less sophisticated analytical techniques] may be unintentionally lost by treatment. […] Until techniques of analysis are developed we do not always know what the potential information is or what treatments would eradicate or distort it. This is often used as a reason for avoiding treatment." (1999: 289) |
| Context | If an object is "part of a larger ensemble […] a treatment such as cleaning, which might enhance value in an isolated object, might decrease its value in context" and or "decrease the value of the whole." (1999: 289) |
| Potential | "The future use of the object contributes to its present value. [Both interventive and non-interventive preventive treatments] are devised to make the object last longer. The primary effect on value is potential. The current exchange value, or aesthetic, symbolic or documentary value may not have changed but the net present value [see N.B.] based on the continued provision of these other values has." (1999: 289)<br>N.B.: The net present value corresponds to the difference between discounted (future) |

[15] See author's entry in Appendix A for a definition of these categories.

| | |
|---|---|
| | benefits and discounted (future) costs, i.e., it is the value today derived from future uses of the object. |
| Condition | "Since it is usually defined in terms of need for treatment, 'condition' will change favourably if material is added or subtracted deliberately, unfavourably if material is lost or rearranged unintentionally." (1999: 290) |

Considering conservation in its broadest sense, Lipe (1984) also mentions some conflicts that may arise between the different values when it comes to deciding how they should be preserved. However, unlike Riegl, for whom societal choices will ultimately dictate conservation decisions, Lipe's considerations in this regard are mostly of an ethical nature, i.e., while acknowledging the importance of a social context in defining values, the author points some reasons why caution is needed when preserving them. For instance, while it is possible to produce fakes, imitations or reconstructions using new materials, the historical pathway that actual past objects crossed may not be falsified or changed; however, it may be "misunderstood and misrepresented […], as can the past cultural contexts from which the material objects have emerged" (Lipe 1984: 5), be it for political or historical manipulations, economic ends, erroneous popular interpretations, or even on aesthetic grounds. Then,

> if we know that the history is false for which, e.g., a monument, building, or battleground is made to stand, we have the obligation to speak out about it. To do less is to declare that the associations of historic things and their meanings are, after all, only conventional, and that any information whatsoever can be attached to these things, for whatever purpose, if only enough of us agree to do so. (Lipe 1984: 6)

Also, new uses and meanings may be added to cultural objects, as it often occurs in the built heritage, and "we as cultural resource advocates must attempt to see that whatever function is added to a resource, the thread of association with its actual historic context is not broken, falsified or entirely submerged in its new fabric." (Lipe 1984: 6) Even if these new uses or meanings are added on aesthetical grounds, the link to the past must not be severed – aesthetic values should not prevail over symbolic or informational values.

Other value conflicts are rooted on decisions driven solely by economic motives. For example, although "Adaptive reuse has saved many historic buildings and districts" (Lipe 1984: 8), to consider the utilitarian dimension alone in preservation planning may risk informational and/or aesthetical values and even damage associative/symbolic values. Likewise, non-economical values (particularly informational values, which are not prone to translation into monetary terms) may be sacrificed to tourism or speculation in art markets. Caution is therefore advised, since, as mentioned above, economic tools are unable to convey all of the values involved in a cultural resource.

Another relevant problem emerges when judgements are made today about how to keep cultural resources for tomorrow. This concern is manifest when dealing with scientific (or informational, or documentary) values, i.e., when deciding what to preserve for future research, since many analytical methods are destructive and there are no certainties about the directions that the diverse disciplines devoted to heritage studies will follow:

> In addition to the testimonial value, there are less evident documentary values that require an understanding of the historic fabric in order to identify their meaning and their message. Since the documentary value responds to evolving questions posed by the community over time, it is important that the material evidence, defined in terms of design, materials, manufacture, location, and context be preserved in order to retain its ability to continue to manifest and convey those concealed values to present and future generations. (ICOMOS Americas 1996: sec. B.3)

Evidently, this problem may also arise when considering associative or symbolic values; however,

> it is the nature of symbols that one or a few can stand for the whole, while it has been the trend of recent informational research to deal with large aggregates or samples of

> artefacts, sites, or whatever, and also to emphasize areal distributions of both cultural and natural phenomena (Lipe 1984: 7)

Hence, anticipating and managing informational needs seems to be much more complex than setting priorities for associative/symbolic values. On the other hand, the interest groups defending resource preservation on grounds of informational values will be relatively small (compared, for instance, with supporters of symbolic values), and thus will need to present each case ever more carefully and consistently.

### *Values-based management*

> *The better a resource is understood and interpreted, the better it will be protected and enhanced.*
>
> The Appleton Charter (1983)

Conceived in the spirit of the principles of the Venice Charter (from where it borrows the term 'cultural significance'), one of the major contributions of the Burra Charter was the formalization of values-based management in cultural heritage: the Burra Charter Process is "a site-specific approach that calls for an examination of the values ascribed to the place by all its stakeholders and calls for the precise articulation of what constitutes the site's particular significance" (Mason et al. 2003: 2). It is arguably this contribution that makes the Burra Charter "the most heavily used doctrinal document in conservation activities, especially in Western countries" (Zancheti et al. 2009: 48).

In the Burra Charter, conservation is viewed as a process, rather than discrete endeavours, which integrates a larger process of site management. In the context of the latter, "the aim of *conservation* is to retain the *cultural significance* of a *place*" (ICOMOS Australia 2013b: art.2, italics in the original document); as seen earlier, for this Charter, the cultural significance of a place incorporates the complete array of values that said place embodies. Yet another interesting aspect to the Charter is its emphasizing that the usage of the place may contribute to its cultural significance; and thus compatible uses should be sought, and practices that help build the significance of a place should be fostered and protected.

The Burra Charter Process is a management model based on cultural significance, where "a sequence of collecting and analysing information before making decisions" (ICOMOS Australia 2013b: art.6) should allow for the understanding of this significance, which, in turn, should take precedence (and preside) over policy development and subsequent management. The Process begins with the identification of place and associations, prioritizing its securing and safety; and, once those are assured, the sequence *significance understanding – policy development – management* may begin.

The management of a heritage site generally focuses on three central goals: conserving its heritage resources, presenting them to visitors and researching them. The implementation of these critical goals generally unfolds into other management objectives, related to activities as diverse as technical conservation interventions, heritage objects interpretation, public managing, infrastructural control and development. These activities are, in principle, assigned to different wardens, and often lack a unifying thread clearly tying each separate effort and framing them under the abovementioned ultimate goals (Mason et al. 2003).

The Getty Conservation Institute (GCI) asserted that a values-based approach, as proposed by Demas (2002) constitutes the most adequate framework for the management of cultural heritage sites (Mason et al. 2003). This type of approach consists chiefly in analysing the values associated to the site and ascertaining the overall significance of the latter, in order to assess the most effective options for the preservation of this significance. One of the main advantages of values-based approaches is their unifying character, promoting the integrated analysis of the often very diverse and sometimes seemingly irreconcilable issues related with the management of a cultural resource, since all the values and stakeholders' expectations are brought into discussion. In fact, a values-based management lies heavily upon the consultation of all the involved stakeholders, whilst realizing how this group has been progressively broadened for most cultural resources once new values are acknowledged to contribute to their significance. In a nutshell, the use of a values-based approach to site management "is characterized by its ability to accommodate many heritage types, to address the range of threats to which heritage may be exposed, to serve the diversity of interest groups with a stake in its protection, and to suggest a longer-term view of management" (Mason et al. 2003: 1).

The assessment of values for a given object, or site, may resort to a variety of sources, of which the most traditional ones are historical and research records, as well as the professional opinion of traditional cultural heritage stakeholders, namely researchers and experts in the areas of history, art history, archaeology, architecture and the like. Today, as new values are recognized to play a part in the significance of an artefact, so are new stakeholders admitted into the circle of managerial influence; thus, cultural heritage stakeholders (the "connected people" of the New Zealand Charter) are now defined as "people for whom the place has special *associations* and *meanings,* or who have social, spiritual or other cultural responsibilities for the place" (ICOMOS Australia 2013b: art.12, italics in the original text) or, more pragmatically, "individuals or groups who have an interest in a site and who can provide valuable information about the contemporary values attributed to the place [; they] can be communities living close to a site, groups with traditional ties or with interests in particular aspects of the site" (Mason et al. 2003: 1).
Most of the values recognized by these different stakeholders are legitimate and, in principle, traditional values, be they aesthetic, historic or scientific, are not to overshadow other more recently acknowledged ones. This does not prevent the fact that some sites have their significance and, where applicable, a subsequent designation, based in the recognition of some specific values, and thus these may gain some ascendancy over others – although never at their expense, as underlined in the Burra Charter.

Once the values are assessed and the significance of the site is established, it is necessary to determine which site (material) features convey which values. This step means answering questions such as: "What about [the material features] must be guarded in order to retain that value? If a view is seen to be important to the value of the place, what are its essential elements? What amount of change is possible before the value is compromised?" (Mason et al. 2003: 2) From this analysis, a clearer understanding of the elements responsible for the significance of the site should ensue, from where protection and conservation plans may be designed. Worldwide, notable heritage-stewarding institutions that implemented values-based management include the Australian Heritage Commission (that abides by the Burra Charter), as well as several of its (earlier mentioned) state-level counterparts; English Heritage (EH); Parks Canada; the United States National Park Service (de la Torre et al. 2005); Historic Scotland (Historic Scotland 2000); and the Heritage Council of Ireland (Nolan & Ruane 2004).

Finally, it should be stressed that the management of a place must accommodate shifts in values. If values are dynamic, then, evidently, a values-based analysis and planning has to be periodically reassessed; also, the efficacy of the chosen options and their impact on the significance of the object needs to be evaluated at regular intervals, and thus values-based management should always function on the basis of periodic plans. This of course does not prevent the necessity of drawing long-term (e.g. thirty years) goals, which prove invaluable to guide medium-term (five years) planning (HWMPC 2008). Each new plan should therefore include the detailed revision of its predecessor – learning from its shortcomings, understanding which objectives were not attained and why and analysing new contexts that may have come into play and how the plan responded to them.
This stance is valid in the context of interventions as well: past significance assessments do not preclude the need for new ones with every new change that is envisaged for a heritage object, since "Successive restoration and preservation actions, using the same statement of significance, tend to reinforce values from the past and set up barriers that prevent the appearance and identification of new values." (Zancheti et al. 2009: 50)

### *Beyond values-based conservation*

*The concept of participation by the local community and stakeholders needs to be stronger than the text* [article 1 of the Nara Charter] *implies in order that they be involved in all processes from the beginning.*

Declaration of San Antonio (1996)

Values-led conservation, as advocated by the Burra Charter and the stewardship institutions mentioned in the previous section, has also been met with criticism by different authors. The chief argument against it is related to the subordinate role forced upon most heritage stakeholders:

> The coordination of, and responsibility over, the overall conservation and management process is in the hands of a strong managing authority. It is this authority that identifies the stakeholder groups, records, measures, and prioritizes their values, decides what stakeholders and values to protect, and how to involve the stakeholders in the implementation phase. (Poulios 2010: 173)

Indeed, in conservation, if (as shown so far) heritage values will conflict, then the interests of their respective stakeholders cannot be symmetrically resolved. 'Tragic choices' must be made. The relevant questions then become *who* will make those choices – and based on which criteria? Albeit promoting the involvement of all stakeholders, values-based conservation does not necessarily frame this participation, which then becomes contingent of each specific context of application; the Hadrian's Wall Management Plan Committee, for instance, noted that

> The strength of the committee is its wide spectrum of interest and comprehensive representation of organisations. One of its weaknesses however is that in the case of organisations that have multi-faceted roles, the breadth of their responsibilities cannot be fully reflected by their single representative on the committee. (HWMPC 2008: 3)

Zancheti et al. (2009) noted that the Burra Charter "does not indicate how this coexistence [of different values/stakeholders] or how prioritizing values must be fashioned in the process of conserving heritage sites" (2009: 49), additionally remarking that the Burra Charter Process "flows according to the deliberations of only one type of stakeholder: specialists." (2009: 49) Aiming at greater inclusiveness, the authors proposition for stakeholder feedback to be clearly added to the significance-understanding steps of the Burra Charter Process: 'cultural significance' is redefined as "the set of all identifiable values resulting from continuous (past and present) judgment and the social validation of meanings of objects" (Zancheti et al. 2009: 51), thus implying that significance assessments, and their ensuing statements, require both judgement and validation amongst stakeholders before being used in policy development and management.

Smith also denounced values-led heritage management as a form of perpetuating a (Western) Authorized Heritage Discourse[16] (AHD) narrative. According to the author, the Burra Charter, or, at least, its 1999 version, "which attempts to incorporate greater community participation in conservation and heritage management matters, effectively works to compromise that participation", since "it has not altered the dominant sense of the trusteeship of expert authority over the material fabric" (2006: 23-24).

Government-appointed stewardship institutions are typically the ones charged with the final decisions in the values-based conservation of heritage sites[17], with their authority "provided legitimacy through the broad involvement of the public" (Poulios 2010: 174), based on the aforementioned discontinuity between past and present, posited by historicist approaches to heritage. The AHD, as Smith notes, is "self-referential" (2006: 28). Demas remarked that, given the subjectivity involved, "Values-based planning is an approach capable of being manipulated, or, for the faint of heart, of being turned into formulas or rules [, thus requiring] honesty,

[16] Discourse is used here to mean "a specific ensemble of ideas, concepts and categorizations that are produced, reproduced and transformed in a particular set of practices and through which meaning is given to physical and social realities" (Hajer, quoted in Smith 2006: 14).

[17] For instance, English Heritage is the chief coordinator of the Committee for the conservation and management of Hadrian's Wall.

integrity, and dedicated practice" (2002: 49). It could be argued, however, that this tendency to filter non-Western contexts and heritage practices through the lens of institutional stewardship demands more than just honesty, integrity and dedication to be adequately counteracted. It has namely been suggested that, because it rests on the shoulders of conservation experts,

> a values-based approach, though expected to equally consider tangible and intangible heritage elements, in practice seems to be primarily concerned with the tangible ones, seeing the safeguarding of intangible elements as incorporated within and serving the conservation of the tangible ones. (Poulios 2010: 174)

Poulios argued that this approach is inadequate to frame the conservation of "living heritage sites", i.e., sites which are

> inextricably linked to a specific community ['core community'] that retains its original association with it throughout time (continuity), by maintaining its function and continuing the process of its spatial definition and arrangement over the course of time to the present. This community cannot define itself — in terms of identity, self-esteem, and physical location — detached from the site; it has the primary role in the conservation and management of the site, and considers the caring for the site its own inherent obligation." (Poulios 2010: 176)

For these sites, Poulios advocates a 'living heritage approach' (Poulios 2014), based on a continuity between past and present, and focusing on a conceptual, rather than material, authenticity, where the core community is the main responsible body for conservation decisions. The living heritage approach is still based on significance, but the values stem from the community that actively practices the site's heritage, and are introduced in the management process without the mediation of conservation experts; while values from outsider communities are contemplated in this approach, they are subsumed in the values of the core community, although combined values-based and living heritage approaches to management may prove beneficial in some cases (Poulios 2014).

Although much is being done towards inclusiveness, some authors (Smith 2006; Wells 2010) argue that conservation is still heavily positivist and elitist and it is thus still far from reaching its due place at the service of past, present and future generations. In the words of Green,

> It is not the experts who will determine what is meaningful to whom and why. A broad social and political process will do this. We [conservation experts] cannot control this, but concerns of the preservation movement will not even be part of this process unless we work to bring it to people where they live. (1997: 94)

After gradually replacing object-based perspectives, it seems increasingly likely that values-based conservation will be, in turn, replaced by more clearly stakeholder-centered approaches.

## *2.2. Principles*

While the previous section mostly dealt with *what* is being conserved; this section is devoted to the *how* it is being (or should be) conserved. Understanding that principles are a means to an end, and not an end in themselves, is pivotal for their definition: in order to be meaningful (and useful) all conservation principles must be defined in reference to the conservation goals; since the focal point in conservation are the values of the object, "ethical principles (reversibility, minimum intervention) are not recognized as actually being principal, but rather as added values relative to the goal of the treatment" (Muñoz-Viñas 2005: 175).

Most conservation principles held today evolved through centuries of object conservation history, and particularly over the past century, when conservation became a more consistent and reflected-upon human activity; but they also reflect societal trends. Conservation practice plays an important role – from his experience as a metal restorer, Ashley-Smith suggests the possibility of practical experience dictating these principles and not the other way around: "behaviours interpreted in retrospect as ethical, and therefore fitting universal guidelines, may well have developed independently and without external influence within specific trades and disciplines" (2009: 14). But what conservation behaviours are considered ethical today?

The introduction to the Venice Charter (ICATHM 1964), to this day a pillar document in the conservation of (material) cultural heritage, emphasizes two central points: how cultural heritage is increasingly considered as a *common heritage*; and how it is our *duty to preserve the authenticity* of heritage for future generations; Jokilehto regarded these two issues as the "crystallization of the essential ideas in the conservation of cultural property" (1988: 267). These points logically lead to the need of considering both the present and the future generations *for whom* heritage is stewarded, and this means acknowledging the full richness of values that may be attached to that heritage.

Considering present stakeholders, Muñoz-Viñas (2005) proposed that conservation ethics must be *adaptive* in order to accommodate the primary goal of preserving the values or meanings that each heritage object has for the group that is affected by it; this means that no conservation principle should be rigidly applied. Also, the application of all principles in one given intervention may prove conflicting, and there may be a need to privilege certain amongst them, depending on the objectives of said intervention.

Our responsibility towards future generations is translated by the concept of *sustainability*, which has been suggested to be "terribly useful" in a context where our perception of heritage extends far beyond the traditional historical and/or aesthetical paradigms (Bluestone et al. 1998). It is from this present and future commonality of heritage – that we strive to preserve – that the principles that guide modern conservation today are derived; they are consecrated in international charters and include: compatibility; minimum intervention; reversibility/ retreatability/removability; discernible restoration; interdisciplinarity; and sustainability. A brief description of some relevant aspects to these principles may be found below.

### 2.2.1. Minimum intervention

The professional guidelines endorsed by the European Confederation of Conservator-Restorers' Organisations (E.C.C.O.) recommend that indirect methods of conservation – preventive conservation – take precedence over direct actions on the object, but also, and notably, that these direct actions should be limited to the absolutely indispensable: "The Conservator-Restorer should take into account all aspects of preventive conservation before carrying out physical work on the cultural heritage and should limit the treatment to only that which is necessary." (E.C.C.O. 2003: art.8), a stance endorsed by the Canadian Association for Conservation of Cultural Property and the Canadian Association of Professional Conservators (2009) as well. The Burra Charter also consecrates the principle of minimum intervention, stating that conservation "requires a cautious approach of changing as much as necessary but as little as possible" (ICOMOS Australia 2013b: art.3).

As a concept, minimum intervention seems to have stemmed from the mid 20th century realisation that direct actions upon a heritage object were, in general, potentially harmful, and that science was not always capable of providing fully safe treatment options (Roudet 2007; Villers 2004). Today, minimum intervention is still considered by many as one of the key directives to bear in mind when planning a conservation intervention.

The issue remains, however, of defining what should be considered a minimum – meaning absolutely necessary – intervention. As put by Caple: "The problem with minimum intervention is that it is not a complete statement. The minimum intervention to achieve what?, and under what circumstances?" (Caple, quoted in Villers 2004: 4)

From a purely materialist viewpoint, many actions would not be considered indispensable for the conservation of a heritage object. Nevertheless, Brandi, defending restoration as a critical act, proposes the (discernible) reintegration of lacunae as a *necessity* for regaining the potential unity of the artwork, without which a lacuna would stand out and relegate the image to the background, thus hindering its apprehension (Brandi 1996). Paul Philippot defended, in turn, that restoration implied the critical interpretation of the artwork and, regarding lacunae reintegration, this meant that "the minimum is in itself suggested by the lacuna, in particular by its location; the hiatus is created regardless of its size" (Roudet 2007: 55), and illusionist reintegrations might apply. Concerning cleaning, however, Philippot was somewhat more restrictive, warning against the perils of losing critical interpretation in favour of scientific or technical solutions applied systematically and without judgement and adverting that "Patina, in fact, is precisely that «normal» effect of time over matter. It is not a physical or chemical concept, it is a *critical* concept" (Philippot, quoted in Roudet 2007: 56, italics by the author).

These opinions should come as no surprise since Riegl argued that prevailing values will be the ones dictating the final goal of the intervention (or even if there should be an intervention) – ergo, what kind of actions will amount to the minimum necessary to achieve the intended result. However, for the relatively long period when the discipline of conservation was approached almost exclusively from an objectivist perspective, value assessments and object interpretations where dismissed on the grounds of their subjectivity; and the concept of minimum intervention, along with that of reversibility, was used within a "positivist mentality of impartiality or neutrality in treating [objects]" (Villers 2004: 3). This may cause minimum intervention to hinder more than help, as "it discourages critical scrutiny by disguising the assumptions, with which it is closely associated, that conservation methodology is objective and that the [object] embodies a single, uncontested history." (Villers 2004: 3)

Villers insightfully argued "that minimal intervention is an attitude, not a principle; that it cannot guide decision making because it fails critically to describe its aim and it is not accountable; that minimal intervention is associated with a positivist methodology when associated with the idea of [a single] history of the object; and it does not take account of context and use" (Villers 2004: 8) She proposes that a 'post minimal intervention' attitude be used instead, that acknowledges the role of the conservator in the writing of the history of the object, the inevitability of change and the relativism of interpretations – and, thus, of conservation interventions (Villers 2004). Relativist approaches are indeed gaining an ever-wider influence in the conservation world, as has been argued throughout this chapter, but it is considered here that the term 'minimum intervention' may nevertheless be kept, since evidence of wider usage of the term coined by Villers was not found and it is considered that it might be confusing. Of course the 'minimum intervention' concept must be redefined to incorporate this new attitude towards objects and their conservation; in other words, it must be referenced with the goal one is trying to achive.

Because of its dependence upon the object and its characteristics, including values and context, intended use, materials and condition, not to mention its stakeholders, it is not possible to rule which specific actions pertain to the domain of the minimum indispensable and which ones do not. According to Roudet (2007), elements that should be considered when pondering over a minimum intervention include:

- the values that we bestow upon the object and their relative importance: as seen previously, values may conflict, and it is the prevailing value(s) that will ultimately dictate both actions and amplitude of the required intervention;
- the use that is and will be made of the object;
- the cultural context that originated the object and the elements that grant its authenticity;
- the intention that created the object (arguably includable on the former).

The consultation of stakeholders and relevant experts should of course be included, as values and contexts, past, present or future, may not be assessed without it. As a corollary, and as defended by Philippot, only a critical interpretation of the cultural object, comprising its context and specificities (including, but not limited to, material aspects), allows for defining what a minimum intervention should encompass.

For Villers, "In comparison with reversibility, or retreatability, minimal intervention is not accountable and cannot be tested" (2004: 4) and, "as it is not accountable, minimal intervention is used to justify a wide range of different treatments" (2004: 4) and therefore "[it] cannot guide decision making" (2004: 8).

### 2.2.2. Reversibility | Retreatability | Removability

Reversibility was a conservation principle adopted mainly due to the failing of some past treatments, in an attempt to protect the heritage objects from the harmful effects they might potentially induce (Sasse & Snethlage 1997); in time, it became widely accepted in conservation practice.

Recent conservation guidelines still contemplate reversibility as a desirable principle – the Burra Charter states that "Changes which reduce *cultural significance* should be reversible, and be reversed when circumstances permit" and adds, in the explanatory notes, that "Reversible changes should be considered temporary. Non-reversible change should only be used as a last resort and should not prevent future conservation action." (ICOMOS Australia 2013b: art. 15, italics in the original text) One should nevertheless note that this is applicable only to "changes which reduce *cultural significance*" and that allowing future treatments is considered mandatory.

In recent years, however, reversibility became "not a requirement, but an ideal to be pursued whenever possible" (Muñoz-Viñas 2005: 191-192). As such, it does not validate interventions that are aggressive to heritage values simply because they are reversible: "Unless of very short duration, crude and intrusive changes are certainly not justifiable simply because they are theoretically temporary or reversible, for they risk becoming permanent" (English Heritage 2008: 47). Or, as Appelbaum puts it,

> As important as the concept of reversibility is in the modem fields of conservation, it does not necessarily have a direct connection with the propriety or advisability of a treatment. An easily reversible treatment may damage an object, and an irreversible treatment may be the best under a particular set of circumstances. (1987: 71-72)

Verification either of the unfeasibility – some authors even defending that reversibility simply "did not exist" (Villers 2004: 4) – or of the contradictions raised by the criterion of reversibility – which, strictly speaking, fails whenever impregnation or cleaning treatments are necessary –, along with critics that relate its use to reducing responsibilities in conservation practice, directed the emphasis towards different principles, and the concepts of retreatability and compatibility (see dedicated section) were put forth (Sasse & Snethlage 1997; Teutonico et al. 1997).

The concept of retreatability was already present in Brandi's *Teoria del Restauro*: his third principle of restoration reads "every restoration should not prevent but, rather, facilitate possible future restorations" (Brandi 1996: 341). As for the term, 'retreatability' was coined by Appelbaum, "for want of a more elegant term" (1987: 67), as an ethical recommendation asserting that treatments performed upon a conservation object should not preclude the future treatment of the latter – after all, "The fundamental reason we do our work is to insure that the pieces we treat will last forever. Therefore, unless it is destroyed first, every piece we treat will be treated again, and some provision *must* be made for future treatment." (Appelbaum 1987: 72); retreatability, Appelbaum demonstrated, is "the core" (2010: 359) of reversibility.

Appelbaum, it must be said, does not oppose the concept of reversibility; she simply argues that its application in practice needs a systematic analysis, since 'reversibility' translates into very diverse considerations depending on the type of treatment[18] being performed; in other words, there is no simple, direct way of measuring reversibility:

> Reversibility is not a simple "yes" or "no" proposition. Within the wide range of treatments of which the results can be undone, there are degrees of reversibility, depending on how much time and trouble are involved, and on what risk it poses for the object. (Appelbaum 1987: 71)

[18] The use of "the term "reversible" [should be confined] to the description of a process rather than of a material" (Appelbaum 1987: 66).

Removability, as retreatability, is a concept that emerged with the realization that full reversibility of a treatment is seldom a practical possibility, thus providing those involved in conservation with a feasible ethical alternative (Muñoz-Viñas 2005). Removability is a conservation guideline which stresses that, when applying materials onto an artefact being conserved or restored, preference should be given to those which are believed to be removable. It should be noticed that this concept implicitly accepts that these materials may (and probably will) have an effect on the material of the artefact, and that these effects may be irreversible; the term was firstly proposed by Charteris (Muñoz-Viñas 2005).

### 2.2.3. Discernibility

Discernibility is chiefly pertinent in the context of additions or reconstructions of missing parts; it does not apply to all the actions typically performed in the scope of a conservation intervention, e.g. cleaning, which often is intended to have a visible outcome or consolidating, which generally is meant to go visually unnoticed.
As mentioned earlier, Boito suggested discernible restoration as a form of solving the architect-restorer's dilemma of responding to his creative urge while respecting the history of the object. Brandi appropriates this concept and turns it into a restoration requirement, necessary for the legitimating of restoration as a part of the history of the object: "the act of restoration, in order to respect the complex historical nature of the work of art, cannot develop secretively or in a manner unrelated to time. It must allow itself to be emphasized as a true historical event – for it is a human action – and to be made a part of the process by which the work of art is transmitted to the future." (Brandi 1996: 232-233) It should be noted that, in spite of the inconsistencies highlighted earlier, Brandi's *Teoria* does present a thorough analysis on the treatment of lacunae in works of art, which is arguably one of the main reasons for its prolonged standing in the field of conservation.

More recently, the Burra Charter states that reconstruction – which, for the purposes of this Charter, is defined similarly to restoration but, unlike the latter, implies "the introduction of new material into the fabric" (ICOMOS Australia 2013b: art.1) – while defendable in certain circumstances, "should be identifiable on close inspection or through additional *interpretation*." (ICOMOS Australia 2013b: art.20, italics in the original document)
Nonetheless, in his defence of adaptive ethics, Muñoz-Viñas contends that, in some contexts, discernible restoration may be contrary to the best interest of the persons affected by interventions on a given object; under these circumstances, it may be more ethically correct to make reintegrations invisible, if that is the form of better preserving the values of the object (Muñoz-Viñas 2005). In acknowledging that, like any conservation principle, discernibility is not a goal in itself and should, instead, be subsumed under the wider frame of significance, this position seems to be the most current in conservation today.

### 2.2.4. Interdisciplinarity

In some way or another, conservation of cultural heritage always maintained a strong connection with history of art, and one may venture to say (as did Choay (2000b)) that these two disciplines *as such* developed hand in hand and that this development finds its roots the same social motivations and attitudes towards heritage. In time, and with the necessity of better understanding decay processes and the best way to tackle them, multidisciplinarity definitely arose within cultural heritage conservation with the critical contributions of several hard sciences; on the other hand, besides history of art, other soft sciences also began engaging in the conservation field.
Nevertheless, professionals involved in the conservation of cultural heritage have, in recent years, remarked that, although the need for multidisciplinary work is duly acknowledged, there is often a lack of interaction – interdisciplinarity – among the several disciplines drawn in: "If one were to map, simply and generally, the current shape of conservation policy and practice,

one would find a rather linear path with different groups of professionals engaged in distinct steps along the way" (Avrami et al. 2000: 3); schematically:

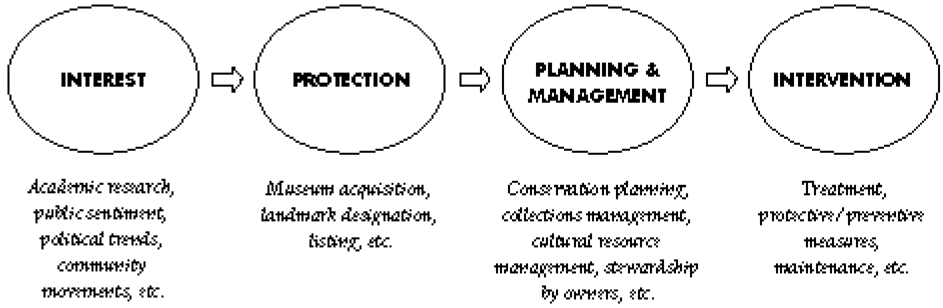


**Figure 2.3:** Pathway of a heritage object, from its production (meaning its recognition as cultural heritage), through its conservation process, until eventually a technical intervention is required – "different aspects of conservation activity often remain separate and unintegrated, retaining the sense that conservation is insulated from social contexts" (Avrami et al. 2000: 4). (source: Avrami et al (2000)).

Two main reasons are suggested for this lack of interdisciplinarity: "the rather fragmented and unbalanced body of work that supports the work of conservation; [and] also […] the specialization of work in different disciplines" (Avrami et al. 2000: 4). The fact that the bulk of the research effort in the conservation field has mainly focused on the physical condition of the object has been highlighted earlier; other fields, such as history or history of art, have contributed with knowledge about specific objects, but this research is not necessarily integrated in an object conservation analysis; finally, more input from disciplines such as anthropology, philosophy, sociology and economics, to name but a few, addressing specifically the conservation field would certainly contribute to a better understanding of contexts and, maybe, help binding these different conservation-oriented expertises together.

The fact is that the need for integrated approaches is considered pivotal for conservation to keep up with the challenges of nowadays rapidly changing society. Furthermore, other disciplines, such as economics, and new branches of already implicated social sciences, are being called in to fill the research gaps that arise as social and cultural circumstances evolve. The urgency of involving policy-makers and other relevant stakeholders in the process of conservation, with a strong focus on the more directly concerned communities, has been stated as critical for the development of conservation as well (Avrami et al. 2000).

### 2.2.5. Sustainability

The most widely adopted definition of sustainability may be found in what is commonly known as the Brundtland Report, which reads: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, n.p.); which means, among other things, considering both intra- and intergenerational equity. Hassler & Kohler hailed "Long-term strategies of sustainable development […], which are ultimately decision-making methods and heuristics" (2001: 241), resorting to sustainability indicators, as key for the integration of "several crucial aspects of cultural heritage conservation" (2001: 243) in policy development towards a management of the building stock "within a broader social, environmental and economic strategy" (2001: 243).
The concept of sustainability was considered to provide workable common ground to the heritage and economics fields, much due to the advances in environmental conservation – a field from which heritage conservation may draw useful analogies, as long as one bears in mind (1) that "whereas the environmental issues and interventions are developed on the strong basis of ecological science, heritage issues have no such theoretical model on which to rely" (Mason 1998: 16); (2) that "direct comparisons to environmental economics" may cause one to "loose sight of distinctive characteristics of cultural heritage, such as its value for national identity" (Klamer & Zuidhof 1998: 27); (3) that cultural and natural conservation may conflict and/or

compete for the same resources (Lockwood & Spennemann 2001); and (4) as seen earlier "extension [of preservation] to economic issues raises difficulties, above all with the dominant neoclassic theory, which relies on a basic behaviourist model which is exclusively individual and short-sighted (discount principle)" [19] (Nanda et al. 2001: 69).

Nevertheless, from this sustainability-based common ground between the systems of economics and culture, Throsby (1995) proposed a "unified framework", termed "culturally sustainable development" (1995: 201) and defined by four criteria on which to base policy analysis:

1. "Advancement of material and non-material well-being", i.e. "characteristics of cultural advancement within a society should also be regarded as integral to the notion of development." (Throsby 1995: 202-203)
2. "Intergenerational equity and the maintenance of cultural capital", which reclaims "fairness in the distribution of resources and opportunities between generations, in particular between present and future generations"; here, 'resources and opportunities' specifically refer to cultural capital, be it physical (i.e., tangible heritage) or intellectual ("the body of ideas, practices, beliefs and so on, together with artworks existing in the public domain (music, literature), that are received from former generations and passed on to succeeding ones") (Throsby 1995: 203)
3. "Equity within the present generation", because societies are also accountable for providing intragenerational equity, e.g., in the "distribution of cultural resources, access to cultural participation, the provision of cultural services for disadvantaged groups, and so on" (Throsby 1995: 204)
4. "Recognition of interdependence", which "implies acceptance of the view that maintenance of cultural processes no less than of biological processes is vital for the continuing development of humankind." (Throsby 1995: 204-205)

The fact is that "the maintenance of cultural heritage seeks to maximize the utility of what we already possess and to use human ingenuity in adapting, rather than replacing, existing buildings or structures" (Burman 2001: 21). Thus, it seems unquestionable that sustainable conservation policies are needed to face the contemporary pressure for a rational use of resources (Burman 2001). Conservation seems conceptually sustainable. In practice, the first step whenever considering sustainable development policies for heritage should be to ensure that this 'adapting' does not compromise significance for future generations.

From the standpoint of (conservation) practice, Muñoz-Viñas (2005) proposed 'sustainable conservation' as one of the core principles of contemporary conservation theory – in fact, as *the* core ground from where ethical considerations regarding conservation may be derived. More precisely, the notion of sustainability highlights the interests of future users as the main impediment for freely disposing of conservation objects in the present; leading the author to suggest that "the conservator has the moral duty to find out the reasons why an object is to be conserved and to learn about its tangible and intangible uses before making decisions that can compromise its usability", considering that "it is the conservator who will likely have to represent the interests of future users" (Muñoz-Viñas 2005: 204).

Nevertheless, the same author alerts to the fact that the concept of sustainable conservation may be a paralyzing one if taken to its extreme interpretation: as we cannot be sure of all the potential values that an object may have for future generations, only preventive conservation would be allowed. This is undesirable whenever it means not meeting the needs of present generations also affected by the object (Muñoz-Viñas 2005); and besides, as mentioned earlier, preventive conservation will also have an impact upon the evolution of the object values.

[19] Discounting future costs and benefits is a "common practice in economic evaluations" that "makes current costs and benefits worth more than those occurring in the future" (Torgerson & Raftery 1999: 914).

### 2.2.6. Compatibility

*Compatibility is thus reached by crossing the 'affinity', the 'analogy' and finally the' homogeneity '*

G. Bonsanti (2003)

Compatibility has become a widely accepted conservation principle of good practice (Delgado Rodrigues & Grossi 2007; Teutonico et al. 1997), and much research is devoted to the finding of compatible solutions for heritage conservation. It is, nevertheless, a relatively new principle: Bonsanti (2003) attributes its first consistent definition to Giorgio Torraca (see entry in the table below), who defined it for supporting the choice of conservation materials in 1986; nonetheless, a few years earlier, the Burra Charter already references the term, albeit in a different scope: "The conservation options will determine which uses are compatible. Compatible uses are those involving no change, changes which are substantially reversible, or changes which have a minimal impact on the culturally significant fabric" (ICOMOS Australia 1979: art. 7).
Table 2.9 lists a few examples of the definition of 'compatibility' in (built) heritage conservation research.

**Table 2.9:** Definitions of *compatibility* used in built heritage conservation.

| Concept and definition | Scope of application | Sources |
|---|---|---|
| **Compatible use**: "a use which respects the cultural significance of a place. Such a use involves no, or minimal, impact on cultural significance" (ICOMOS Australia 2013b: art.1). | Site management | The Burra Charter (ICOMOS Australia 2013b) |
| **Compatible use**: "a **use** which is consistent with the **cultural heritage value** of a **place**, and which has little or no adverse impact on its **authenticity** and **integrity**." (ICOMOS New Zealand 2010: 9, boldface in the original text) | Site management | New Zealand Charter (ICOMOS New Zealand 2010) |
| **Adaptive reuse compatibility**: compatibility is judged through the assessment of the following indicators: architectural integrity, public perception (of the significance of the building), form, new function and sustainable adaptation. | Reuse of heritage buildings | (Elsorady 2014) |
| **(In)compatibility indicators**: compatibility extent of a given conservation product or action, rated according to its "potential as inducer of negative (harmful) effects for the conservation objectives" (Delgado Rodrigues & Grossi 2007: 37): | | (Delgado Rodrigues & Grossi 2007) |
| Physical-chemical indicators: describing intrinsic material properties for the assessment of changes induced by the conservation product/method. | Assessment of conservation products (incl. techniques of application): consolidants; repair mortars; water repellents. | |
| Environmental indicators: concerning the interaction of the conservation action/product with the surrounding environmental conditions. | Assessment of conservation actions/ interventions | |
| Operational indicators: regarding both human and logistical resources available for the action/ intervention at planning and execution stages. | Assessment of conservation actions/ interventions | |
| Socio-cultural indicators: related to the impact of the action/intervention on the local context and vice-versa. | Assessment of conservation actions or interventions | |
| **Compatibility**: "introduced treatment materials will not have negative consequences [upon the historic substrate]" (Teutonico et al. 1997: 294) at mechanical, physical and chemical levels. | Assessment of conservation actions and products: cleaning, | (Sasse & Snethlage 1997) |

| Concept and definition | Scope of application | Sources |
|---|---|---|
| Chemical compatibility, specifically, means not only no "undesirable reactions between treatment materials and the historic substrate", but also no formation of "harmful by-products" nor "nutrient sources for encouraging biological growth" (Teutonico et al. 1997: 294)<br>Compatibility translates into compliance with '**tolerance limits**' defined for different selected properties and based on the values of the unweathered stone as reference, as per the proposal in Sasse & Snethlage (1997).<br>**(Retreatability**: "possibility of applying a new treatment without negative results" (Teutonico et al. 1997: 295)) | consolidants, repair mortars, coatings, hydrophobes. | (Teutonico et al. 1997) |
| **Compatibility:** Conservation principle "requiring that the materials added should join the original ones without causing mechanical damage (e.g., due to a different thermal expansion or a different elastic modulus) or chemical (e.g., because of formatting soluble salts or other harmful products) or physical (e.g. due to a different porosity and permeability)"<br>(Torraca [1986], quoted in Bonsanti 2003: 4) | Assessment of conservation products | (Torraca [1986], quoted in Bonsanti 2003) |
| **Compatibility**: in principle, it would be assured by similarity between treated and untreated stone in terms of moisture expansion, thermal expansion, and elastic modulus. | Assessment of consolidants | (Doehne & Price 2010) |
| **Compatibility**: requirements that products must fulfil "as much as possible" (Moropoulou et al, 2000, p.228), before and after using, in conservation interventions; these may be:<br>- chemical: based on the (chemical) similarity between the heritage material and the materials deposited/formed by the product;<br>- physical: related to the effects of consolidation on the water and vapour permeability and thermal expansion coefficient of the treated (heritage) material;<br>- mechanical: to be analysed case by case;<br>-aesthetical: relating to colour changes. | Assessment of consolidants | (Moropoulou et al. 2000) |
| **Compatibility**: conceptual requirement meaning that "introduced treatment materials will not have negative consequences" (Van Balen et al., 2005, p.782). To be applied together with the concepts of: 'retreatability'; 'durability'; 'sustainability' and 'harmonization' (aesthetical compatibility) via translation into 'functional requirements' and 'technical requirements' at aesthetical, chemical, mineralogical, physical and mechanical levels (Schueremans et al. 2011).<br>More specifically, "a compatible and/or retreatable repair mortar is a mortar that behaves in a similar way as the old mortars, to different types of action (e.g. static, hydrothermal) and that does not create or aggravate new types of [technical, esthetical or historical] damage." (Van Balen et al., 2005, p.783). | Assessment of repair mortars | (Van Balen, K. et al. 2005)<br>(Schueremans et al. 2011) |
| **Compatibility**: compliance with the following requirements (adapted from Veiga (2007: 87)):<br>- no inducing of damage to pre-existing elements;<br>- ability to protect pre-existing elements;<br>- no causing of disfigurement to the building.<br>Physical and chemical acceptability limits are defined based on the characterization of historical mortars. | Assessment of repair mortars | (Veiga, R. 2007)<br>(Veiga, Rosário et al. 2010)<br>(Freire et al. 2015) |
| **Reverse engineering**: compatible mortars are designed to meet acceptability limits based on similarity and defined by the understanding of historical mortars, especially in terms of physical-chemical and mechanical properties and microstructural characteristics. | Assessment of repair mortars | (Moropoulou 2000b)<br>(Moropoulou et al. 2005)<br>(Papayianni |

| Concept and definition | Scope of application | Sources |
|---|---|---|
| Papayianni proposes a similar approach, adding that "the most crucial parameters for designing compatible repair mortars […] seem to be the appearance, the strength, the gradation and porosity" (1998: 190) | | 1998) |
| **Compatibility**: the repair mortar should (adapted from Silva et al, 2014, p.208):<br>- be formulated considering the features of the existing/original mortars, with similar constitution and appearance (when possible);<br>- be no stronger than the existing mortar;<br>- be considerably weaker than the masonry units and deform significantly before failure;<br>- have similar or greater permeability to water and to water vapour than the existing masonry materials;<br>- have good workability and be easy to apply.<br>Assessment resorting to the methodology proposed by Delgado Rodrigues and Grossi (2007) | Assessment of repair mortars | (Silva et al. 2014)<br>(Silva et al. 2015) |
| **Compatibility**: "capacity of the repair mortar to interact with the original historic substrate without inducing any decay." | Assessment of repair mortars | (Klisińska-Kopacz et al. 2008) |
| **Compatibility**: "[quantification or prediction of] the interaction time (on a historical scale) of two juxtaposed stones on a building (one of which is original and the other is a replacement) subjected to various factors alteration. (…) a correct compatibility [exists] when no differential alteration manifests between the two stones in time." (Dessandier 2000: 43)<br>**Durability and Compatibility Index (IDC)**: measure of durability properties (compression resistance, water uptake coefficient, capillarity coefficient, presence of reactive clays) of a given stone, to be used in comparison with those of another stone. A 'correct compatibility' should be achieved by using replacement stones with a similar IDC to the "original" ones. | Assessment of replacement stones | (Dessandier 2000) |
| **Compatibility**: replacement stones should be similar to pre-existing stones in terms of: structure; texture; mineral composition; porosity; pore size distribution; water absorption coefficient; saturation coefficient; water vapour diffusion resistance; compressive strength and modulus of elasticity. Acceptability ranges based on pre-existing stone values are provided for the last five criteria. | Assessment of replacement stones | (Snethlage & Sterflinger 2011) |
| **Aesthetical compatibility**: visual imperceptibleness to a (naïve) observer. To be added to other requirements, e.g. values of mechanical and water-transfer properties "defined around those of the original stone" (Concha-Lozano et al. 2013: 356). | Assessment of replacement stones | (Concha-Lozano et al. 2013) |
| **Colorimetric similarity**: $\Delta E^*_{ab} < 3$ | Assessment of replacement roof slates | (Prieto et al. 2011) |

Smars insightfully remarks that "The definitions of compatibility can change but three elements are always present: some differences, a changing environment and permissible damages." (1998: 1), concluding that "Compatibility is always relative and good interventions should be decided and worked out on the base of the actual stakes, the values." (1998: 4)

The EN 15898:2011 Standard defines 'compatibility' as the "extent to which one material can be used with another material without putting significance or stability at risk" (CEN 2011: 10). This definition has the merit of being short and (relatively) direct but it focuses on materials, making its application somewhat limited. Delgado Rodrigues & Grossi contend that "the concept of compatibility can be used in several dimensions, namely to qualify a certain product or material […], a certain product applied in a specific way […], an action with several components […] or a complete conservation intervention" (2007: 33). This assertion is confirmed by some of the references listed above. Even if not explicitly stated, the key concept underlying *all* of these specific definitions is undoubtedly that of 'significance' and it is proposed that a more encompassing definition than that of the CEN Standard may be written as follows:

> **Compatibility corresponds to the extent to which a product, method or action may be used upon a heritage object without putting its present or future significance at risk.**

Attention is drawn to the following:

(1) the use of the noun 'extent' highlights the fact that 'compatibility' is not a sharply defined feature and that a judgement is necessary in order to evaluate the compatibility of any given product/method/action;

(2) the noun 'stability' was considered to excessively emphasize the material dimension of the concept, and therefore removed; it was re-interpreted as contemplating the future significance of the object and the phrase was modified accordingly.

(3) Although not explicitly mentioned, 'authenticity' and 'integrity' are implicitly considered, since the significance of a heritage object depends on the first condition and is qualified by the second.

## *2.3. Some remarks*

Riegl was one of the first authors to recognize that it is the values societies attach to heritage objects that distinguish them from common objects, and that those values have suffered, and will continue to suffer, shifts in their definition. Even if there are universal values voiced by society through its heritage, these are not intrinsic to the objects but, rather, are bestowed upon them by social groups of variable size, in variable moments in time.

Today, a multitude of values joins the aesthetical and historical values that were traditionally conferred to heritage objects; many of these contemporarily-recognized values are srongly communal in character, including educational, recreational or touristic values, or those related to setting, local contexts or international influence, among others, thus reinforcing the role of the subjects (or stakeholders) in building and conserving heritage[20]. Given the inclusiveness of what may be considered to possess cultural value, one of the chief merits of the Burra Charter is precisely to have drawn attention for the necessity of defining these values and thus better understand the object. As a corollary, because of changes in peoples' perceptions, values evolve. Throughout history, (Western) societies seem to have initially valued sites for reasons strictly connected to their original function (military, religious, and so forth); but new values were progressively added, while others were lost or dimmed. These values all share a more or less close relationship with the fabric of the place, or the materiality of the object: "Cultural significance is embodied in the *place* itself, its *fabric, setting, use, associations, meanings*, records, *related places* and *related objects*"[21] (ICOMOS Australia 2013b: art.1, italics in the original document).

[20] "[Material] heritage is valued in a number of different, sometimes conflicting ways. The variety of values ascribed to any particular heritage object […] is matched by the variety of stakeholders participating in the heritage conservation process." (Mason 1998: 2)

[21] In its first article, the Burra Charter gives the following definitions (ICOMOS Australia 2013b: art.1, italics in the original document):

- 'Place': "site, area, land, landscape, building or other work, group of buildings or other works, and may include components, contents, spaces and views."

On the other hand, it is interesting to note that, for instance, social values, as defined by English Heritage, seem to "tend to be less dependent on the survival of the historic fabric" (English Heritage 2008: 32), oppositely to spiritual values, which seem to evolve in a manner closely connected to the fabric of the place. It should come to no surprise, then, that, as already asserted by Riegl, it is this straight link between the values and the materiality that embodies them that will eventually dictate conservation decisions.
Economic tools may prove helpful in the assessment of heritage values by measuring the utility or welfare that people withdraw from heritage existence; techniques used for the valuation of heritage may assist cost-benefit analyses and, thus, conservation decision making at site, regional or national levels. They cannot, however, represent the sole ground for basing decisions, as they are unable to convey the multiplicity of values involved in a heritage object.

Authenticity and integrity are other concepts that must integrate heritage analysis. These are not values, and cannot be augmented (although they can be diminished), and may be construed as a requisite and a qualifier of significance, respectively. For World Heritage sites, and along with a statement of significance, describing the values that each given site embodies, UNESCO recommends that statements of authenticity and integrity are periodically issued as well. An authenticity assessment will ascertain the veracity and reliability of the information sources pertaining to the site, while assessing integrity means to evaluate the wholeness of the site when it comes to conveying its values.

Yet another important aspect to Riegl's work is the theorizing of the conflicts between values when it comes to conservation decision making; this axiological approach to conservation proved useful and since became a research focus for several authors, as well as a decision-making tool for different heritage authorities. The concept of value seems to provide a useful framework for analysing these conflicts and for negotiating and deciding in conservation, as long as the choices are clearly formulated, so as to make interventions legitimate and intelligible to present and future generations. Of course this implies a clearer responsibility for the decision-makers, but it also supplies them with a tool for trading and negotiating the meanings at stake and those that are to be preserved.

As already hinted by Riegl, and clearly asserted more recently (Taylor & Cassar 2008), the concept of value is not of an homogenous nature, and various types of values make up for the overall value of a heritage object. As such, *value* could be contemplated as a "multifaceted matrix" (Richmond & Bracker 2009: xiv) or, better still, as a spectrum that cannot be considered under a single scale of measure (Taylor & Cassar 2008); those different types of values that compose the overall value of the object will shift in time and space at different rates, demanding for a multi-perspective approach that tries, as much as possible, to understand these shifts and their impact in the overall value of the object, i.e., its significance.
From here follows the definition of *conservation* proposed by EH: "the process of managing change to a significant place in its setting in ways that will best sustain its heritage values, while recognising opportunities to reveal or reinforce those values for present and future generations." (English Heritage 2008: 7) Likewise, a conservation intervention should be seen in the broader

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- 'Fabric': "all the physical material of the *place* including components, fixtures, contents, and objects."
- 'Setting': "the area around a *place,* which may include the visual catchment."
- 'Use': "the functions of a place, as well as the activities and practices that may occur at the place."
- 'Associations': "the special connections that exist between people and a *place.*"
- 'Meanings': "denote[s] what a *place* signifies, indicates, evokes or expresses" which "generally relate to intangible aspects such as symbolic qualities and memories."
- 'Related place': a "place that contributes to the *cultural significance* of another place";
- 'Related object': "an object that contributes to the *cultural significance* of a *place* but is not at the place."

context of the continuum that forms the history of the object, i.e., as part of a process, rather than as a discrete occurrence.

Conservation principles assist decisions concerning *how* conservation should be performed. It is presupposed, then, that *what* should be conserved in any given object is assessed prior to making said decisions. In other words, as we assume the responsibility of conserving heritage for present and future generations, we should firstly assess the significance we are trying to preserve and only then discuss the best ways of preserving it. These will largely depend on the people affected by the object, i.e., those that bestow values upon it, but the uncertainty relatively to future values has to be contemplated as well.
This is why the need for adaptive conservation principles, i.e., principles that respond to the various reasons for which each given heritage object is preserved, has been highlighted. On the other hand, the concept of sustainability advises on the uncertainty about future generations, suggesting caution when approaching the conservation of an object (albeit not to a paralyzing extreme) – our actions and choices, including the choice of taking no direct actions, will have an impact on the objects and, thus, on the values we aim at preserving.
Nevertheless, the principle that presently seems to best lend itself to being translated into an operative tool for supporting decision making in conservation interventions is the *compatibility* that any such intervention must strive to respect: it is a widely acknowledged principle that may be applied at different decision levels, allowing for the assessment of conservation interventions, actions or products; and it offers a conceptual framework that is adaptable while remaining anchored to the *raison d'être* of conservation, i.e. heritage significance.

# 3. Research methods & tools

*The conservation and restoration of monuments must have recourse to all the sciences and techniques which can contribute to the study and safeguarding of the architectural heritage.*

The Venice Charter (1964)

Scarcity of resources such as time, money, and effort force the deciding between alternatives to allocate them; managing a site entails daily decisions regarding its interpretation, access and conservation, including intervention planning. In principle, these decisions should be anchored in a conservation strategy that mirrors the concerns of society when tending to its heritage. In its "Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment", English Heritage (EH) stresses its intention "to strengthen the credibility and consistency of decisions taken and advice given by English Heritage staff, improving [their] accountability by setting out the framework within which we will make judgements on casework" (English Heritage 2008: foreword). This emphasis on *credibility*, *consistency* and *accountability* implies a need for less ambiguous decision-support tools in the realm of heritage conservation. Even if each case is unique, decisions should be framed by a common ground of principles that meet the each society's perspectives on their own heritage; these should be clearly stated, so that decision making becomes indelibly transparent and intelligible.

In the past decades, management strategies have become more and more explicitly based on the conservation of the significance of the object (or site), as exemplified by the Burra Charter Process, its supporting Conservation Management Plan, the English Heritage Guidelines or the Getty Conservation Institute's value-led conservation. On the other hand, a growingly preventive approach to heritage led to the adaptation of risk management procedures to conservation. In what it aims at minimizing risks, risk management seems to be a useful complement to values-led management and its safeguarding of values. Works on the risk management of museum collections and on disaster preparedness, which help coping with important threats to heritage objects, are nowadays widespread.

When it comes to planning *interventions*, however, neither the minimization of risks nor the safeguarding of values seem to have been clearly translated into operative tools. In fact, proposals supporting the planning of conservation interventions are scarce in the conservation literature, at least for the built heritage. Appelbaum's *Conservation Treatment Methodology* (2010), whilst offering valuable lessons, is chiefly applicable to movable heritage objects. Lazzarini & Laurenzi Tabasso's comprehensive *Il Restauro della Pietra* (1986) is an extremely

helpful manual, but it does not offer a planning guide for the development of what the Charter of Krakow terms the "project of restoration" (ICC Krakow 2000: art.3).
Within the scope of Prodomea ('PROject on high compatibility technologies and systems for conservation and DOcumentation of masonry works in archaeological sites in the MEditerranean Area'), a methodology was proposed that supports intervention planning using compatibility as the operative concept, advising for choices to be made that minimize the (in)compatibility of the action towards the heritage object. This method may be assisted by performance-based assessments, which answer many questions at the products and actions level, even if clear performance-based decision criteria are yet to become consensual.
The reasoning behind the assessment tools proposed within the Prodomea DSS was to divide the factors deemed important in (built heritage) conservation interventions into measurable parameters, to be assessed separately and subsequently computed together, thus providing a systematic support to decision making. Systematizing performance assessments in such a way had been previously achieved by Sasse & Snethlage (1996, 1997), but the Prodomea methodology would apply it further than product testing, as will be shown below.

One of the chief merits of these approaches is undoubtedly their promoting of less ambiguous decision making: the recommended steps encourage a comprehensive and systematic assessment of different options and prevent potentially important aspects from being disregarded, thus allowing planners to make more informed choices.
In decomposing the evaluation of 'compatibility' into diverse workable parameters, these methods also agree with the fact that, when used as a conservation principle, this concept does not allow for absolute classifications, as highlighted earlier; in all likelihood, no action or product will be fully compatible towards any given heritage object. However, these systems provide planners with comparative measures of the available choices; and assist in identifying potentially damaging situations before they occur. In their goals, therefore, they do not differ substantially from risk assessments, even if systematization was achieved by virtue of an in-depth knowledge on built heritage materials rather than by following a risk assessment textbook. It is then worth exploring the contributions that may be gained from the application of risk assessment tools to conservation decision making in the scope of intervention planning.
A summary description of these methods and tools is given below, divided in three main sections: DSS for built heritage conservation interventions; Risk assessment, and its applications in built heritage conservation; and the Delphi method.

## 3.1. Planning built heritage conservation interventions

*The difficulty that characterizes management of the conservation process lies in identifying the specific motivations that influence decisions on the strategy to follow and on the action to be taken.*

J. Delgado Rodrigues & A. Grossi (2004)

As discussed earlier, compatibility has been proving relatively popular in the field of heritage material studies, particularly when it comes to product selection. Pioneering this type of concept application was the work by Sasse & Snethlage (1996, 1997), who were among the first to deconstruct conservation actions into manageable indicators that could be ascribed threshold values towards less ambiguous evaluations. Delgado Rodrigues & Grossi took the concept one step further by integrating their own Compatibility Indicators (CIs) into a planning methodology encompassing the whole conservation intervention process.
The fact that both sources propose limits, or thresholds, for the evaluation of conservation treatments and/or products is highlighted, since citations of these limits became widely held in stone conservation literature, sometimes with adaptations and/or in combination with other parameters. A brief description of the two proposals is given in the sections below.

### 3.1.1. Sasse & Snethlage's *Methods for the Evaluation of Stone Conservation Treatments*

***Setting evaluation thresholds***

In the context of performance assessments, the papers by Sasse and Snethlage (1996, 1997) undoubtedly deserve a special reference. In fact, these authors proposed one of the most systematic and comprehensive methodologies for the evaluation and assessment of the main categories of procedures used in stone conservation, namely: cleaning, consolidation, repair mortars application, coating and water-repellence treatments.
In one of the papers, the authors start by highlighting that they will be addressing "only the scientific and technical aspects of conservation" (Sasse & Snethlage 1997: 224) and that "Materials and methods are discussed with respect to the question of whether they enhance or decrease future degradation, distress or decay" (Sasse & Snethlage 1997: 224). Although conservation principles stated in international charters ultimately constitute the theoretical background for the research presented, ethical considerations are left out of this particular discussion and, on this subject, the authors opt to refer the reader to other texts.
Concerning the establishment of 'tolerance limits', stated by Teutonico et al. (1997) as a necessary requirement of the compatibility and retreatability principles, Sasse and Snethlage underline that the available knowledge did not yet allow for a rigid definition and that, as such, all the requirements proposed by the authors "should therefore be considered preliminary, based on the present experience; further systematic research is needed to confirm their validity." (1997: 225)

In terms of structure, the proposal begins with the listing of the different testing methods that the authors deem necessary to accomplish the evaluation of each type of conservation procedures; in these tests, unweathered stone is used as reference material, "which can either be measured on the back side of sufficiently deep drill cores from the object or on freshly quarried stone samples" (Sasse & Snethlage 1997: 226). This choice allows for the implementation of the general guiding principle that presides to the proposal: "it should be the aim of a treatment to return the altered properties to their starting point – not to make the stone «better» than would have been brought about by geology" (Sasse & Snethlage 1996: 86).

Given the diversity of factors that play a role in the deterioration of historic stone, "it is evident that a single parameter cannot be sufficient to evaluate the effectiveness of a treatment. There is a set of selected properties that is needed to describe the behaviour of the material" (Sasse & Snethlage 1997: 225).
Along with stating a set of tests for each evaluated procedure/product, the authors suggest tolerance limits that should be met in each test method in order to ensure the required compatibility and retreatability. Although these tolerance limits are preliminary, as previously mentioned, and still need research for validity support, the comprehensiveness of the covered testing methods makes this one of the most solid departure points for a performance-based decision making. An example of the proposed tolerance limits is displayed in Table 3.1.

**Table 3.1:** Sasse & Snethlage's requirements for the evaluation of hydrophobic and nonhydrophobic stone strengtheners (Sasse & Snethlage 1997, Table 12.3)

| Symbol | Property | Dimension | Test Method | Requirement[1] |
|---|---|---|---|---|
| | | **Laboratory Tests** | | |
| – | Visual properties | – | DIN 6174[2] | Slight color change only ($\Delta E \leq 5$), no darkening, gloss or increased susceptibility to soiling |
| – | Application | – | – | ≤ 30% of the capillary pore volume filled with water |
| $w$ | Water uptake coefficient | $kg/m^2\sqrt{h}$ | DIN 52 617[2] | $w_i \leq w_o$ |
| $B$ | Water penetration coefficient | $cm/\sqrt{h}$ | DIN 52 617[2] | $B_i \leq B_o$ |
| $s$ | Penetration depth | cm | Capillary soaking for 5 min. | Deeper than zone of maximum mean moisture; $w = 0.1...0.5$, $s = 1.0$ cm; $w = 0.5...3.0$, $s = 3.0$ cm; $w > 3.0$, $s = 6.0$ cm ($w$ = untreated stone). In cases of dense crusts and deterioration of rain-sheltered areas the thickness of the damaged zone is to be considered. |
| $\alpha_{Hv}$ | Hygric dilatation | µm/m | Hygric and overhygric range | No increase against untreated stone |
| $\alpha_{TH}$ | Thermal dilatation | $K^{-1}$ | –20/0+20/+40 | No increase against untreated stone |
| $\mu$ | Value of water vapor diffusion resistance | – | DIN 52 615[2] wet cup | Increase ≤ 20% |
| $A_{SI}$ | Sorption isotherm (SI) | – | Storage under 0/ 15/30/50/65/75/85 /95% RH, 20° C | $A_{SL,i} \leq A_{SL,o}$; area under the SI after treatment ≤ area under the SI before treatment; no extra sorption in the raange RH 70...95% |
| – | Drying rate | h | 20/65 $v \leq 2$ m/s | Drying time until moisture content at 20/65: $t_i \leq 1.2\ t_o$ |
| $\beta_{BFS}$ | Biaxial flexural strength | $N/mm^2$ | Drill core slices with double ring load, storage 20/65 | $\beta_{BFS,i} \approx \beta_{BFS,o}$ homogeneous strength profile, strength increase of the weathered stone up to the strength of the unweathered stone |
| $E$-modulus | Modulus of elasticity | $kN/mm^2$ | Static or dynamic $E$-modulus | $E_i \leq 1.5\ E_o$ |
| $\beta_{POS}$ | Pull-off strength | $N/mm^2$ | Storage 20/65 | $\beta_{POS,i} \approx \beta_{BFS,o}$; homogeneous strength profile, strength increases up to strength of weathered stone |
| – | SEM examination | – | SEM | Formation of grain–grain bridges, adhesion and grain surface filming, filling of clay mineral aggregates |
| | | **Tests Applicable on the Objects** | | |
| – | Drilling hardness | – | Drill hardness meter | Homogeneous strength profile, strength increase up to strength of unweathered stone |
| $w$ | water uptake coefficient | $kg/m^2\sqrt{h}$ | Karsten tube | $w_i \leq w_o$ |

[1] Subscript ($o$) relates to the unpainted stone, subscript ($i$) to the painted stone.
[2] Or comparable method.

### *A 'Complex Effectiveness Evaluation' system for consolidants*

Based on their own experience and on a proposal by D. Honsinger, the authors furthermore developed a 'Complex Effectiveness Evaluation' system, applicable to stone consolidants.
This effectiveness evaluation starts by defining, for a given building (or stone type), *limits* of effectivity for each parameter; it is additionally recommended that *classes* of effectivity be established, where, for each given parameter, ranges of acceptable values between minimum

and maximum effectivity are to correspond to percentages of the optimum value. The values of these limits, as well as the scale and range of the effectivity classes, are "to be decided by a competent authority" (Sasse & Snethlage 1997: 232). As can be noted in the example given in Table 3.2, the evaluation encompasses both effectiveness and harmfulness parameters, albeit the authors note that "several important properties are still missing, such as compatibility (e.g., thermal shock, humidity changes, mortar influences) and durability (e.g., freeze-thaw, weathering)" (Sasse & Snethlage 1997: 242).

**Table 3.2:** Sasse & Snethlage's 'Complex effectiveness evaluation system' for film-forming consolidants (1997, Table 12.7)

| | | | Classes of Effectivity | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Wt | Formula | 0 | 25 | 50 | 75 | 100 |
| Penetration depth mm in 28 d | 20 | | $d \leq 15$ | $15 < d \leq 30$ | $30 < d \leq 50$ | $50 < d \leq 70$ | $h < 70$ |
| Adhesion of polymer film | 10 | | Everywhere superficial detachment | Local superficial detachment | Local bubbles | Sporadic bubbles | Perfect film |
| Degree of hydrophobation, $t$ = time, $v_w$ = water uptake rate, $w_w$ = water uptake | 20 | $v_w = dw_w/dt$ | $v_{wi} > 0.3$ | $0.3\ v_{wo} > v_{wi} > 0.2\ v_{wo}$ | $0.2\ v_{wo} > v_{wi} > 0.1\ v_{wo}$ | $0.1\ v_{wo} > v_{wi} > 0.01\ v_{wo}$ | $v_{wi} \geq 0.01\ v_{wo}$ |
| Drying behavior, $v_d$ = drying rate, $w_d$ = water release | 10 | $v_d = d_{wd}/dt$ | $v_{di} < 0.85\ v_{do}$ | $0.85\ v_{do} < v_{di} < 0.9\ v_{do}$ | $0.90\ v_{do} < v_{di} < 0.95\ v_{do}$ | $0.95\ v_{do} < v_{di} < v_{do}$ | $v_{di} \geq v_{do}$ |
| Water vapor diffusion, $p$ = coefficient, $wdd$ = water vapor diffusion intensity | 10 | $p = wdd_i/wdd_o$ | $p \leq 0.3$ | $0.3 < p \leq 0.5$ | $0.5 < p \leq 0.7$ | $0.7 < p \leq 0.9$ | $p > 0.9$ |
| water vapor sorption, $A_{si}$ = area between isothermes $o$ and $i$, $A_s$ = area under isotherm $o$ | 10 | | $A_{si} \leq 0$ | $0 < A_{si} \leq 0.15\ A_{so}$ | $0.15\ A_{so} < A_{si} \leq 0.3\ A_{so}$ | $0.3\ A_{so} < A_{si} \leq 0.4\ A_{so}$ | $A_{si} \geq 0.4\ A_{so}$ |
| Hygric dilatation, $\varepsilon_\infty$ = final dilatation | 20 | $t_\varepsilon = 0.1\ \varepsilon_\infty$ | $t_\varepsilon < 0.12\ h$ | $0.12\ h \leq t_\varepsilon < 1.0\ h$ | $1.0\ h \leq t_\varepsilon < 3.0\ h$ | $3.0\ h \leq t_\varepsilon < 6.0\ h$ | $t_\varepsilon \geq 6.0\ h$ |
| $i$ = treated, $o$ = untreated | $\Sigma = 100$ | | | | | | |

On the other hand, the system also allows for the weighting of the different parameters obtained from the tests required for the characterization of each conservation procedure. It is quite evident that the several parameters listed for the consolidation (or any other given product/procedure) assessment should not have the same relevance in the final evaluation. However, the issue of deciding which parameters are relatively more important, and how much exactly they should weight in the final decision, is a question that remains complex. Of course, no strict rules may be defined, and each case has to be examined carefully in its several facets, but some guidelines should nevertheless be possible. For consolidants, these papers clearly state that "Among the listed properties, penetration depth, hygric dilatation and *E*-modulus have the highest priorities" (Sasse & Snethlage 1997: 237). The diagnosis of each particular object, including environmental constraints, should allow for the establishment of the weight that should be ascribed to each parameter, again "to be decided by a competent authority" (Sasse & Snethlage 1997: 232).

Once both limits of effectivity and importance weight are defined for each of the assessment parameters, the overall effectivity may be estimated, as follows:

$$E = \frac{\sum_{i=1}^{n} m_i . w_i}{\sum_{i=1}^{n} w_i}$$

, where:

- ***m*_i**: measured values (as percentages of optimum values) for parameter *i*
- ***w*_i**: importance weight for parameter *i*

Its name notwithstanding, this overall evaluation system is relatively simple and logic, although one of its key aspects remains to be solved, namely the ascription of optimum values and importance weights by the 'competent authority', whose responsibility is too large to take its constitution lightly. Questions on how many members, or experts, or authorities, or affected users, would it take for a reliable opinion to be issued, for instance, might pose some difficulties. Also, the authors highlight that "the method can only be used by experts and in no case schematically" (Sasse & Snethlage 1997: 242). Another relevant issue before this method may be put in practice is, obviously, and as mentioned by the authors, the need for further research to support the definition of requirements, or tolerance limits, for each given parameter, seeing as these are also needed to define thresholds for the effectivity intervals. Attention is furthermore drawn to the risks of computing linearly dependent variables, such as water transport and pore space parameters, into the system.

***Applications***

Laurenzi Tabasso & Simon emphasized that, when choosing a conservation product or cleaning method, "The evaluation of experimental results is the most critical step of the whole testing procedure", and "limits of acceptability should be established, making reference to the value of the same parameter for the undamaged stone, as proposed by Sasse and Snethlage" (2006: 77-78). Specifically for repair mortars, Charola & Henriques also use Sasse and Snethlage's work to stress the "importance of setting tolerance limits with reference to the masonry material itself" (1998, n.p.).
Several authors reference the proposals by Sasse & Snethlage for the assessment of conservation products for stone materials, and notably repair mortars and consolidants. For instance, Bromblet (1999) uses the repair mortar requirements to demonstrate the compatibility, or lack thereof, of air lime-based mortars towards three stone types commonly found in French built heritage. Comparing the requirements with his experimental results, Bromblet furthermore draws a few considerations on the suitability of lime-based mortars for stone repairs, e.g. "air lime based mortars should be used if the substrate has low mechanical strengths and/or high porosity, capillarity" (1999: 336). Sasse & Snethlage's requirements also informed performance evaluations of lime-based mortars as stone repair materials in a PhD dissertation by Lawrence (2006); and both requirements and reasoning were incorporated by Isebaert et al. (2014) in their own proposal of compatibility requirements for repair mortars following an extensive literature review on the topic.

Toniolo et al. (2011) use the consolidant requirements for the evaluation of the mechanical and visual properties of consolidated historical mortars, asserting the applicability of Sasse and Snethlage's proposal to substrates other than stone. Verganelaki et al. (2014) also borrow the consolidant requirements for the harmfulness assessment of a calcium-oxalate–silica nanocomposite for stone consolidation and Vicini et al. (2013) use them for the evaluation of different consolidants applied in the Italian Argo sandstone. The colour requirement for stone consolidants is frequently quoted, examples including, for instance, (Miliani et al. 2007) and (De Muynck et al. 2010). Moreau et al. (2008; 2008) consistently refer Sasse and Snethlage's requirements to demonstrate the efficacy of water-repellent treatments.
The examples found in the consulted literature suggest that Sasse and Snethlage's requirements are mostly taken verbatim, i.e., with no adaptations or additions proposed, even when other tests are deemed necessary.

### 3.1.2. The (In)compatibility Approach

*In the assessment of compatibility between ancient masonry and conservation actions (especially those involving new products and techniques), the quality of the relationship becomes of primary importance, more so than the quality of a product defined in terms of its range of performance characteristics.*

J. Delgado Rodrigues & A. Grossi (2004)

The main goal of Prodomea – "PROject on high compatibility technologies and systems for conservation and DOcumentation of masonry works in archaeological sites in the MEditerranean Area" – was "to transform existing and scattered conservation strategies on archaeological masonry into a more compatible, structured and sustainable one" (PRODOMEA 2004: 4).

The fact is that a conservation intervention does not encompass strictly technical conservation necessities alone; and even these cannot always be fully anticipated and thoroughly planned for in a systematic manner:

> While it is true that recovery and maintenance often comprise a great number of microactions, dependent on situations that are rather unpredictable and therefore conducted unsystematically, there are also some parameters, such as urgency, timeliness, control, opportunity, convenience and economy that predominantly or in combination govern the decision of whether or not to undertake an action. Then there are non-technical but strategic factors that determine the necessity of an action. (Delgado Rodrigues & Grossi 2004: 4)

On the other hand, as previously highlighted, conservation should be seen as a process within a larger strategy of site management, and hence the quality and its maintenance over time should be ensured, as much as possible, from the outset of each given intervention. International charters provide guidelines for decision, but they largely consist of broad directives that leave plenty of room for different choices.

The Prodomea DSS, as its alternative name, the Compatibility Approach, indicates, builds upon the concept of compatibility, using it as the key criterion for the classification and selection of conservation interventions. The concepts of retreatability and minimal intervention are, however, also given significance –, along with compatibility, they constitute the "three key issues related to the concept of quality of conservation and restoration actions" (Delgado Rodrigues & Grossi 2004: 8). Furthermore, it is noted that the concepts of minimal intervention and compatibility share a common purpose of risk minimization.

Within this approach, one of the interesting features of the concept of compatibility is its adaptivity to different levels, from a smaller to a larger scale, i.e., permitting to classify a given product or its application technique, an action composed of a set of procedures or a conservation intervention as a whole; this versatility, however, is only possible if the concept is not too rigidly defined. On the other hand, "It seems clear that «compatibility» cannot be defined in absolute terms and independently of the case in consideration, but rather it should be defined and applied within well-defined contexts, and it requires that the situations and the problems are known with enough detail." (Delgado Rodrigues & Grossi 2004: 24)

The Prodomea DSS was designed in a way that permits it to be used either for the evaluation of past interventions or for the planning of future ones. In both cases, the user is assisted by the (In)compatibility Assessment procedure, which guides them through the analysis of the degree of compatibility of conservation actions or products towards the heritage objects they refer to. In the case of past interventions, this procedure may help analyse or monitor performed treatments and identify best and not so good practices; in what concerns planning, "the aim is to help in choosing the less Incompatible intervention processes, or the best intervention concept, or the more appropriate intervention actions" (PRODOMEA n.d.), by accompanying the planner through each phase of the conservation process. Both the DSS and the Assessment procedure are briefly described in the following sections.

### *The Eight-Step Planning Model*

*Decision-making is the link between the various classes of knowledge that a conservator must accumulate and forms a bridge between expertise and action.*

J. Ashley-Smith (2001)

Within the frame of Prodomea, the planning of conservation interventions is approached as a detailed methodology guiding the planner through each step in a sequential structure. Eight steps were identified as critical for structuring a well-planned conservation intervention, grouped under 'pre-project', 'project' and 'post-project' phases. Some of these steps will imply a control of the (in)compatibility of the different choices, using the (In)compatibility Assessment procedure described in the next section. The figure below illustrates the sequence of the Compatibility Approach Eight-step Planning Model and how the (In)compatibility Assessment procedure plays into the different steps.

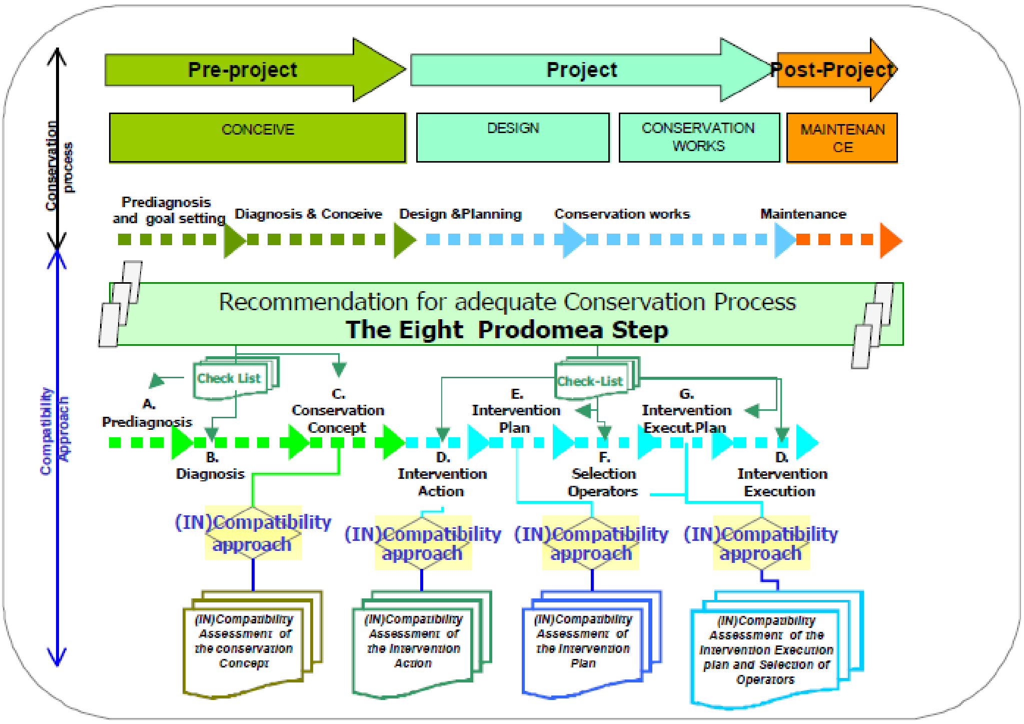


**Figure 3.1:** "The (In)Compatibility Approach as a Design Tool of new interventions" (source: (Grossi 2005: 7)). Eight steps, from 'prediagnosis' to 'intervention execution', should be followed when conducting a conservation intervention; in some of these steps, (in)compatibility assessments should be performed to inform decision making.

The table below describes the different steps in terms of specific planning items, key-actors and (In)compatibility Assessment requirements:

**Table 3.3:** The Compatibility Approach to planning conservation interventions (adapted from (PRODOMEA n.d.))

| Step | Key-actors | Required actions | (In)compatibility assessment |
|---|---|---|---|
| Prediagnosis | Site manager (coordinator) and consultants | - production of photographs<br>- architectural investigation<br>- archive investigation<br>- significance assessment (*)<br>- mapping of distinctive materials<br>- mapping of degradation forms<br>- preparation of a statement of significance (*)<br>- preparation of report on Prediagnostic Phase | none |

| Step | Key-actors | Required actions | (In)compatibility assessment |
|---|---|---|---|
| Diagnosis | Site manager (coordinator) | - sampling planning<br>- lithological and petrological characterization<br>- characterization of material properties (stone, mortars, plasters, etc.)<br>- characterization of construction and artistic techniques (**)<br>- structural stability and seismic hazard<br>- interpretation of damage processes (damage assessment)<br>- production of report on Diagnostic Phase | none |
| Conservation concept | Site manager (coordinator) | - definition of the objectives to be achieved<br>- consider ethical principles (**)<br>- definition of actions to be performed (**)<br>- consider traditional arts and methods and options between modern/traditional materials<br>- identification of actions to be avoided<br>- involvement of the local community<br>- involvement of the scientific community<br>- taking into account local social & cultural issues<br>- taking into account the natural and anthropic dynamic of the territory<br>- definition of the intervention phasing<br>- production of report on Conservation Concept | - operational<br>- socio-cultural |
| Intervention action | Conservation scientist | - consideration of environmental stress | - environmental |
| | | - selection of materials to be used | - physical-chemical |
| | | - definition, execution and interpretation of trials experiment<br>- consideration of effectiveness and harmfulness/compatibility (**)<br>- definition of technical solutions (**)<br>- definition of application procedures<br>- understanding hierarchy and sequence of actions<br>- understanding interaction between actions<br>- production of report on Intervention Actions | - operational |
| Intervention plan | Site manager or consultant | - definition of the logistics requirements<br>- definition of the relevant tools, equipment and methodologies (**)<br>- definition of the documentation needs (**)<br>- consideration of maintenance needs and intervention durability (**)<br>- identification and interference with other site actions<br>- consideration of (further) research needs (**)<br>- planning the sequence & hierarchy of the actions<br>- identification of needed skills<br>- definition of a health and safety plan<br>- plan to inform the community about the intervention (**)<br>- consideration of the costs (consider alternatives) (**)<br>- definition of the request-for-tender format (**)<br>- production of report on Intervention Plan<br>- preparation of the request-for-tender documents (**) | - operational |

| Step | Key-actors | Required actions | (In)compatibility assessment |
|---|---|---|---|
| Selection of operators | Site manager | - consider the team composition/skills<br>- consider the availability of operators<br>- consider the training of craftsmen<br>- consider the relevant tools, instruments and methodologies<br>- consider the costs<br>- consider the documentation issues<br>- consider the execution time planning (**)<br>- consider tender evaluation criteria (**)<br>- production of report on Selection of Operators | - operational |
| Intervention Execution plan | Contractor and Site manager as supervisor | - make up the appropriate team composition<br>- consider the incorporation of local operators<br>- consider the training of local craftsmen to be inserted in the team<br>- guarantee the availability on the site of the necessary tools and instruments<br>- define the appropriate methodologies<br>- prepare the detailed expenses plan<br>- define a documentation plan | none |
| Intervention execution | Contractor and Site manager as supervisor | - respect the intervention plan<br>- respect the safety plan<br>- interaction with site responsible<br>- register all the intervention actions<br>- complement the damage mapping<br>- prepare the detailed report on Intervention Execution<br>- control the execution<br>- control the materials<br>- control the execution process | - operational<br>- socio-cultural<br>- physical-chemical |

(*) Actions proposed here for inclusion on the 8-Step Planning Model, following the conservation goals established in Chapter 2.
(**) Actions added by Revez et al. (2012) following a case-study application of the model.

As mentioned, this Planning model may also find a useful application in the compatibility assessment of former interventions; this usefulness was demonstrated for the 2006-2007 conservation intervention undertaken at the Monastery of Santa Clara-a-Velha (MSCV), in Coimbra (Portugal), as reported at the 12th International Stone Congress:

> The Prodomea DSS seems to be able to tackle complex conservation intervention planning processes; it is both comprehensive and adaptable enough to respond to the multiplicity of aspects that must be considered within the scope of a built heritage conservation intervention […] Most probably, the application of this DSS to the planning of the MSCV intervention would have helped to prevent some inconsistencies and resolve beforehand some of the problems that were raised during conservation works. (Revez et al. 2012: 10)

Also, given the concepts discussed in Chapter 2, it is suggested here that the actions ‘significance assessment’ and ‘preparation of a statement of significance’ should be added to the ‘Prediagnosis’ step, in order to more clearly stress their importance in the intervention planning process.

### *(In)compatibility Assessment*

*Without a formal structure or a common assessment scale for all items, judgments are impossible to evaluate objectively. They can be inconsistent, biased, or both.*

R. Waller & S. Michalski (2004)

The Prodomea First Technical Report highlights that

> most conservation interventions, even in archaeological sites, carry a certain level of risk and that it is neither technically nor economically feasible to advise that only interventions without risk should be acceptable. Therefore, the ultimate achievable aim is certainly *not to find «perfectly compatible» actions, but to find those that minimize the degree of incompatibility* (2004: 4, italics in the original document).

The (In)compatibility Assessment procedure, as proposed by Delgado Rodrigues & Grossi (2007) in the framework of Prodomea, is a tool to assess the performance of conservation interventions, but also to tackle the complexity of decision making in conservation; it is "the heart of the relationship between the site and the Conservation action" (PRODOMEA 2004: 4). The approach endeavours to verify to what extent a given intervention was or will be compatible with the heritage object it is designed to conserve; considering the broadness of the term, the authors propose furthermore that this compatibility be ascertained by analysing the different aspects that, together, make up for the overall impact of the intervention on the object.

In effect, due to their complexity, conservation interventions cannot be analysed with resort to one parameter alone. Thus, in order to fully appraise all the aspects involved, the authors propose that the analysis of the overall performance of interventions should rely in a set of "simpler and workable components", designated by Compatibility Indicators (CIs) and relatable to what other disciplines refer to as performance indicators (Delgado Rodrigues & Grossi 2007). The interest of this decomposition is its allowing us to separately quantify different aspects involved in a conservation process that are inherently too heterogeneous to be evaluated concurrently. On the other hand, these separate assessments should ultimately allow for the overall judgment of the process under appraisal, and thus should be performed in a fashion that permits a final computing of the influence of all the chosen parameters.

For this assessment, Delgado Rodrigues & Grossi borrow the following definition of compatibility: "an intervention or a treatment shall not cause any damage (technical or aesthetical) to the historic material. The intervention or the new material must be as durable as possible" (Final Report of the EU-project POINTING, quoted in Delgado Rodrigues & Grossi 2007: 34). In order to better structure the proposed methodology, the authors suggest the definition of an intermediate level of categories, also labelled the 'first order branches' of a 'compatibility tree [analysis]', under which the CIs deemed necessary will eventually be grouped. These branches encompass broad groups of factors that the authors believe to influence the conservation interventions (Delgado Rodrigues & Grossi 2007):

(i) the <u>physical content</u> encompasses the set of parameters that measure the performance of the intervention in physical-chemical terms, including the (material) impact of products and actions on the conservation object;
(ii) the <u>operational background</u> aggregates indicators for the evaluation of operative (immaterial) aspects that impact on intervention quality, namely possibilities and constraints related to planning, practice, skills, tools;
(iii) the <u>socio-cultural context</u> aims at translating the effects that the intervention will have on the social setting (particularly local communities) that frames the object and vice-versa;
(iv) the <u>environmental constraints</u> cover the potential impact of the environmental setting upon the intervention action and products.

These first-order branches are applicable to different steps of the conservation intervention, allowing for technological assessments but also contemplating management and planning issues. The latter should define the conservation process quality, and may be evaluated by measuring, via operational and social parameters, the interactions of the intervention with its broad (exterior) context and within its own framing; technological assessments will chiefly depend on the physical and environmental parameter sets.

The CIs grouped under each of these branches are "assumed to be quantifiable in terms of their potential influence in the overall incompatibility" (Delgado Rodrigues & Grossi 2007: 36). By definition, each indicator is only supposed to mirror a partial aspect of the whole incompatibility degree, and thus must not be isolated or taken out of its context, at the risk of misleading the assessment process; also, as stated, this procedure assumes that the relative importance of each CI in the overall analysis is rateable. Because of "the large number of potential CIs that can be individuated and in the large differences that can be ascribed to their respective roles" (Delgado Rodrigues & Grossi 2007: 36), not to mention that many prospective CIs may be correlated, the precise choice of CIs must be conducted with caution, as well as the rating of their relative importance in the final incompatibility value. Similarly, defining some indicators as critical (i.e., forcing its appraisal) or complementary for the final result will only add to a more reliable analysis if carried out with caution.

While listing a set of CIs for each first order branch that cover most typical situations found in conservation interventions, Delgado Rodrigues and Grossi stress that the listings are not (and may not be) rigidly defined to cover every situation and that "the users of this methodology have to adapt it to the specific context of their interest, namely according to the combination of internal and external factors, the availability of data and the importance of the problem in question." (2007: 36)
The rating system of the CIs translates them into quantified components of the final (in)compatibility degree, thus allowing to compute very distinct features, originally expressed in different units or even qualitatively; each CI is rated on an integer scale from 0 to 10 according to its incompatibility potential. Again, the authors stress that "The rules suggested for the rating process are a first approach to the problem and although some of them found some support in personal research data or in the available literature, some others are just based on logical and comparative reasoning." (Delgado Rodrigues & Grossi 2007: 37) Tables listing some of these proposed parameters and respective ratings are presented below.

**Table 3.4:** Delgado Rodrigues & Grossi's (in)compatibility indicators and ratings for consolidants for stone surfaces (2007).

| Criteria | Compatibility indicators | Incompatibility risks (rating scale) |
|---|---|---|
| Chemical and mineralogical composition | Presence of clays | Absent → 0<br>Minor amount → 5<br>Significant amount → 10 |
| | Presence of salts | Absent → 0<br>Minor amounts → 5<br>Significant amounts → 10 |
| Pore space | Total porosity | Risks depend on the substrate and on the type of product. Of little value for compatibility approach |
| | Type of voids | Equidimensional pores → multiply the final risks by 1.5<br>Fissures type voids → multiply the final risks by 0.6 |
| Visual properties | Total colour difference (ΔE*) | Lesser than 3 → 0<br>Between 3 and 5 → 5<br>Higher than 5 → 10 |
| Thermal properties | Thermal expansion coefficient of the stone substrate ($\varepsilon_s$) | $[0.9\varepsilon_s < \varepsilon_{ts} < 1.1\varepsilon_s] \rightarrow 0$ |
| | Thermal expansion coefficient of the treated stone ($\varepsilon_{ts}$) | $[1.1\varepsilon_s < \varepsilon_{ts} < 1.2\varepsilon_s] \rightarrow 5$<br>$[\varepsilon_{ts} > 1.2\varepsilon_s] \rightarrow 10$ |
| Mechanical properties | Bending strength<br>Compressive strength<br>Modulus of elasticity<br>Drilling resistance (S & TS) | Values different by less than 10% → 0<br>Values between 10 and 25% higher → 5<br>Values higher than 25% → 10 |
| Treating ability | Penetration depth | Higher than 20 mm → 0<br>Between 5 and 20 mm → 5<br>Less than 5 mm → 10 |
| Hydrophilic behaviour | Water absorption coefficient<br>Water vapour permeability<br>Drying index (S & TS)<br>Hydric swelling | Values different by less than 10% → 0<br>Values between 10 and 25% lesser → 5<br>Values lesser than 25% → 10<br>Lesser than or equal to untreated → 0<br>Higher than untreated → 10 |

S, stone; TS, treated stone.

**Table 3.5:** Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for operational conditionings at planning level (2007).

| Criteria | Compatibility indicators | Incompatibility risks (rating scale) |
|---|---|---|
| Intervention phasing and conceptualisation | Definition of objectives and targets | Good → 0 |
| | Elaboration of a conservation concept | |
| | Diagnostic phase and incorporation of existing information | Fair → 5 |
| | Filling gaps in information | None → 10 |
| | Definition of actions/Project | |
| Intervention planning | Sequence and hierarchy of actions | Logical and justified → 0 |
| | Interaction among actions | Some gaps and doubts → 5 |
| | | No planning → 10 |
| Team composition | Identification of needed skills | Properly done → 0 |
| | Available skills | Relevant missings → 5 |
| | Definition of responsibilities | Critical missings → 10 |
| Scientific and ethical principles | Minimum intervention | Properly considered and assumed → 0 |
| | Compatibility concern | Relevant missings → 5 |
| | Effectiveness and harmfulness | Critical missings → 10 |
| Costs | Alternatives | Considered → 0 |
| | Cost control plan | Not considered → 5 |
| Maintenance plan | Durability assessment | Considered and well done → 0 |
| | Inspection and monitoring | Relevant omissions → 5 |
| | | Absent or critical omissions → 10 |
| Documentation of the intervention | Of the start-up situation | Considered and well done → 0 |
| | Of the works carried out | Poorly done → 5 |
| | | Absent or with critical errors → 10 |

Finally, a global incompatibility degree is obtained by integrating all the rated parameters in a formula such as (Delgado Rodrigues & Grossi 2007):

$$ID_n = \sqrt{\frac{R_1^2 + R_2^2 + \ldots + R_n^2}{n}}$$

Where:

$ID_n$ = Incompatibility Degree

$R_1, \ldots, R_n$ = ratings of the $n$ parameters deemed relevant

In this case, the root mean square is suggested as a means to emphasize the importance of higher (more incompatible) ratings. If it is concluded that some parameters have a higher incompatibility-inducing potential than others, weights may be ascribed, above or below 1, to account for their corresponding influence in the overall $ID_n$; the formula then becomes (Delgado Rodrigues & Grossi 2007):

$$ID_n = \sqrt{\frac{\sum_{k=1}^{n} W_k R_k^2}{\sum_{k=1}^{n} W_k}}$$

Where:

$ID_n$ = Incompatibility Degree

$W_k$ = weight of the *kth* parameter

$R_k$ = rating of the *kth* parameter

$n$ = number of relevant parameters

The final result will vary between 0 and 10, which correspond, respectively, to a fully compatible or to a fully incompatible action or product.

Attention is drawn by the authors to the importance of unequivocally stating the number of parameters, since a lower number may produce a lower $ID_n$ and lead to misinterpretations. On the other hand, the parameter listing may also serve as a checklist to identify the most compatible options within a given conservation intervention. The authors furthermore highlight that "important benefits can arise from the analysis of the individual values given to some specific indicators, namely to those considered as critical ones" and that it is recommended to "revisit the indicators that have received ratings in the upper third part of the scale (8–10), discuss the impact of those indicators and seek for adequate measures to deal with the expected consequences of such high ratings." (Delgado Rodrigues & Grossi 2007: 42)

***Applications***

Many authors have been drawing attention to the necessity of further research into the definition of objective compatibility requirements for the evaluation of heritage conservation products; examples include Zacharopoulou (2011) and Torney et al. (2014), both recognizing the multifaceted nature of the concept and recommending Delgado Rodrigues & Grossi's approach as a base to build research upon. Similarly, the thresholds defined in the (In)compatibility Assessment have been borrowed by several researchers to judge the compatibility (or harmfulness) of stone conservation materials. As encouraged by its authors, the method has also been adapted by some researchers to their particular circumstances and/or research needs.
For instance, López-Arce et al. (2010) use the colour threshold when assessing the behaviour of a nano-lime consolidant applied in a dolostone; Tulliani et al. (2011) borrow it to evaluate the colour compatibility of an hydrophobic consolidant on plaster; whereas Karoglou et al. (2011) use it to complement their reverse-engineering approach to the choice of restoration plasters for the Hellenic Parliament. Mosquera et al. (2010), Illescas & Mosquera (2011, 2014) and Xu et al. (2012; 2015) consistently reference the CIs for water vapour permeability and colour when evaluating the "possible negative effects" (Mosquera et al. 2010: 6745) of diverse organically-modified TEOS (tetraethoxysilane) consolidants applied on a biocalcareous sandstone (Illescas & Mosquera 2014; Mosquera et al. 2010) and on high-purity limestones of high porosity (Illescas & Mosquera 2011), both naturally (Xu et al. 2012), and artificially weathered (Xu et al. 2015); Cappelletti et al. (2015) reference the same CIs in their assessement of silicon-based hydrophobes for the protection of restoration mortars.

More recently, Silva et al. (2015) borrowed the CIs for repair mortars and suggested a few alterations to their (in)compatibility assessment, based on findings from testing mortars with several different binder formulations. Besides the indicators suggested by Delgado Rodrigues and Grossi (2007), including type of binders, coefficient of water absorption by capillarity, drying index, coefficient of water vapour diffusivity, and compressive strength, Silva et al. (2015) observed that pore size distribution and ductility should be included as well. Pore size distribution, measured "through the intrusion volume in various diameter ranges" (Silva et al. 2015: 357), would replace porosity, since the observed differences in the porosity values of the different tested formulations "did not contribute to a correct discretization of the incompatibility risks of the mortars" (Silva et al. 2015: 357), whereas "the porous structure of the mortars has serious implications on their water transport and mechanical properties and, thus, on the overall compatibility with ancient masonries" (Silva et al. 2015: 359). Ductility, in turn, to be "evaluated through the compressive to flexural strength ratio" (Silva et al. 2015: 357), was included as an indicator of the modulus of elasticity.
Regarding the ratings, the authors felt the need of introducing, for the majority of the repair mortar indicators, an intermediate rating between a 'low' incompatibility value – 0, attributable to measured differences between the substrate and the repair mortar below 10% – and a 'medium' incompatibility value – 5, classifying differences between the substrate and the repair mortar between 10% and 50%. The authors therefore proposed that a rating of 2, corresponding to a 'medium low' incompatibility, should be ascribed when the measured differences between the substrate and the repair mortar fell between 10% and 30%.

Tuduce-Trăistaru et al. (2010) adapted the CI reasoning to the choice of consolidants for wooden objects. The authors propose a set of compatibility criteria, along with compatibility indicators, which "are in fact performance parameters relevant to the properties of [wood] consolidation materials" (2010: 221). The scheme also includes ratings, or weights, given in a ten-point scale, for the different indicators, mirroring "their importance in the wood conservation field" (Tuduce-Trăistaru et al. 2010: 221): properties measured by the indicators are either 'essential', 'important', of 'medium importance' or merely 'recommended'. The proposal was "based on a critical analysis of the currently employed wood consolidation products" (Tuduce-Trăistaru et al. 2010: 223) and seems to indicate that other fields of research in heritage conservation main benefit from Delgado Rodrigues & Grossi's approach to compatibility.

One last note for the procedure proposed by García & Malaga (2012) for choosing an anti-graffiti product for heritage masonry buildings, based on the concepts of ‘suitability’ and ‘durability’: in selecting a range of properties for product evaluation in which acceptability thresholds are recommended, the systematization achieved in this procedure follows the ones proposed by Sasse & Snethlage (1996, 1997) and Delgado Rodrigues & Grossi (2007), with the same goal of reducing ambiguity in product choices. Since none of these latter proposals encompasses anti-graffiti product testing, the García & Malaga (2012) procedure would possibly be an interesting addition to either of the said proposals. In the case of the (In)compatibility Assessment, nevertheless, some research would be required to make the anti-graffiti assessment properties more clearly dedicated to the concept of compatibility, since, currently, these properties assess both harmfulness and efficacy, in the short and long run.

## 3.2. Risk assessment

*Cultural heritage is always at risk. It is at risk from the depredations of war. It is at risk in the face of nature's occasional eruptions and irruptions. It is at risk from political and economic pressures. It is at risk from the daily forces of slow decay, attrition and neglect. It is even at risk from the hand of the over-zealous conservator!*

Herb Stovel (1998)

Risk assessment is one of the key stages of risk management. In broad terms, risk management provides scientific support to decision making in a context of uncertainty. This support is developed along two main spheres: one, concerning the assessment of risk; and the other, which deals with the forms of mitigating it. In the past decades, risk management has known an increasingly widespread development in several fields, among which those related to Engineering and Economics are prominent; risk management has also been hailed as a critical strategic tool for institutions to cope with sustainability (Sage 1998). Depending on the specific field where risk management is applied, the necessary tools for risk assessment and mitigation may vary, but there are, of course, common principles that characterize this type of approach.

The application of risk management to cultural heritage has known important developments in recent years, reflecting the growing importance placed by society in preventive, rather than reactive, approaches to heritage conservation; as well as its recognized benefits in fostering stakeholder participation and governance transparency and accountability (Smars et al. 2012). Some of the most well-known examples of this application include the risk assessment methodology proposed for museum collections by Waller & Michalski (1994; 2004), the ICOMOS Heritage at Risk (H@R) Programme, and the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) guidelines developed for World Heritage sites (Stovel 1998). The following subsections offer a brief introduction to risk management, with a special focus on risk assessment, i.e. risk analysis together with risk evaluation; an outline of the Risk Index method, which is the risk analysis method used in this dissertation; and, lastly, some examples of how risk management tools have been used in the built heritage conservation field.

### 3.2.1. Risk concepts

*The future is no longer viewed simply as progress; it is seen as a risk that can be assessed.*

U.Hassler & N.Kohler (2001)

In the context of risk management, the term *risk* may be defined as the value corresponding to the combination of the likelihood of occurrence of undesirable events with their possible consequences. To identify a risk implies looking into (at least) the scenario, the likelihood of its occurrence, and its related outcomes, although progressively complex systems may demand

further analyses, such as initiating events, system responses and outcomes, or exposure factors and consequences (Caldeira 2005).
*Risk analysis* comprises the procedures aiming at identifying and quantifying or qualifying, within a given system, the undesirable events, the mechanisms that may trigger each event, the respective system responses and the associated consequences – including estimates of extension, amplitude and probability of loss occurrence (Caldeira 2005). *Risk evaluation*, in turn, involves considering the admissibility of the estimated risk; when coupled with risk analysis, it is designated by *risk assessment*.
*Risk management* comprises both risk assessment and the ensuing decision-making processes aiming at risk control, including mitigation, observation/monitoring and reporting/ communication. In a nutshell, risk management implies the identification, analysis, evaluation, communication, mitigation and control of risk(s) and thus, when systematically applied, it is helpful not only in increasing safety, but also in raising quality and/or "minimiz[ing] losses and maximiz[ing] gains" (AS/NZS 2004a: v). Risk management may also lead to changes in the concept of projects and/or to the sharing of risk by the different intervening parties (Caldeira 2005).

Risk assessment may be performed globally, relatively or specifically, meaning it may assist different planning levels – a *global* assessment (at a macro level, e.g. government level) may help define tolerability and acceptability limits and guide strategic and policy planning, including resource allocation; *relative* risk assessment will be needed for the prioritization of interventions, providing a more rational understanding of undesirable events (probabilities of occurrence and potential damage) in given time frames; finally, a *specific* risk assessment will guide specific works, especially during the project phase, allowing for the comparison of alternatives, viability analysis and definition of specific tolerability and acceptability limits, for instance. When applied to a specific intervention, the benefits of risk assessment include (adapted from Caldeira 2005):

- during the intervention: it facilitates the communication among the diverse actors and it promotes a group problem-solving approach, thus allowing for the sharing of the risk between the site manager and the contractor, which minimizes the negative impacts of uncertainties associated with the intervention;
- after the intervention: it facilitates observation and monitoring, as well as the planning of maintenance and of warning/alert tools.

Risk assessment may aid conservation decision making by presenting more effective and rational solutions (Nanda et al. 2001); in the present context, it is expected that the "systematic and logical method" (AS/NZS 2004a: v) in which risk management is based allows for the building of a heritage cleaning compatibility assessment procedure, since the main goal of a risk assessment is "to provide evidence-based information and analysis to make informed decisions on how to treat particular risks and how to select between options" (IEC 2009: 7). Risk management may be implemented at different scales, with different scopes; in some situations, resorting to risk analysis solely may be sufficiently fruitful. Risk analysis may prove useful in project planning, for comparing different options, choosing the best tender format, for quality control, etc.

*Risk analysis* is the first phase of any informed risk management process; and it should be performed in sequential steps, starting with the (1) identification of its scope and goals; followed by the (2) identification of the possible hazards; the (3) identification of the consequences, including estimates of their magnitude and probability of occurrence; and, finally, by the (4) estimation of the risk.
The scope, as well as the detail, of a risk analysis will depend on which questions need to be answered and on which decisions need to be made. It may be delimited by time, space, nature of risk, consequences, degree of uncertainty, and so forth; it may be the study of the total risk or it may focus on a specific risk (Caldeira 2005). As for the goals, these will generally be related to safety factors and/or social impact of damaging events; in certain situations and due to the complexity of the analysis, it may be useful to limit the study to specific risks.

Identifying the possible hazards and their consequences means listing, *for each identified hazard*:

(1) its causes or trigger events;
(2) its damaging mechanisms;
(3) the possible scenarios, i.e. the system responses to the hazard;
(4) the vulnerability factors affecting the system;
(5) the possible consequences.

This data will permit to estimate the risk, which amounts to combining the occurrence likelihood of the hazard causes, mechanisms and ensuing scenarios, with the dimension of each possible consequence. Depending on how they describe the probabilities of occurrence and the potential damage, risk analyses may be qualitative (descriptive) or quantitative (numerical). Quantitative risk estimates commonly resort to Event Tree Analyses, often very complex; descriptive risk analyses that use Likert scale-type rankings, such as the one proposed by Michalski & Waller (1994; 2004) for museum collections, or the Risk Index Analysis proposed here (see next section) may prove more feasible and still provide extremely helpful guidance.

Because the hazard consequences need to be defined, more often than not dealing with risk means dealing with values, and the way they shift with the occurrence of an undesirable event. This implies a valuation process that allows for different risks to be ranked and prioritized, since larger losses in value (or utility, or benefits) are of course synonyms with greater risks (for risks with the same probability of occurrence). As noted by Ashley-Smith,

> The study of risk is concerned not only with probability but also with impact. If there is an equal probability of two unfortunate events occurring, they can be distinguished by the different impacts they will have. The impact will be detected as damage, that is, a loss in usefulness, a loss in value, or a loss in the stream of benefits. There are understandably relationships between value, utility and benefit. To that extent they can be considered together as manifestations of the same thing. If we can determine relative values we can rank them. We can say that because this loss in value is greater, then this impact is greater and so this risk is greater. This allows us to prioritize our risk management options. (Ashley-Smith 1999: 82)

In the *risk evaluation* phase, the previously identified risks are appraised in terms of their admissibility. This step will depend on the perception and acceptability that is socially accorded to each specific risk, which will, in turn, depend on (1) ethical, cultural, economical and political factors, among others; (2) the origin of the risk (natural, imposed or volunteer) and its incidence (individual or societal); and (3) the available information. These will therefore be determinant for the valuation of risks, which will increase, for each society, with exposure, limitedness of information and danger aversion (Caldeira 2005).

The definition of acceptability and tolerance limits is also within the scope of risk evaluation and the most widely used approach, originally defined for societal risk, divides the risks in three regions (Mansoux 2000):

- unacceptable, where only in extraordinary circumstances can risks be justified;
- tolerable or ALARP ('as low as reasonably possible'), where either "risk reduction is impracticable or its cost is disproportionate to the improvement gained", bordering the tolerance limit; or, at least, the "cost of reduction would exceed the improvement gained", bordering the acceptability limit (Mansoux 2000: 11);
- acceptable, where the concerned population/stakeholders finds the risks to be low enough and adequately controlled.

Within the tolerable and acceptable regions, the reduction of risks always implies a trade off between costs and benefits and thus, when human lives are not at stake, the limits are generally based in cost-benefit analyses and expressed in monetary values (Caldeira 2005).

Risks considered acceptable need to be periodically monitored and reviewed, so as to ensure they remain acceptable; unacceptable risks, on the other hand, need to be mitigated. *Risk control* includes all actions and decisions leading to the maintaining or reducing either of the probabilities of occurrence of the undesirable event (preventive actions) or of the seriousness of its consequences (protective actions). Besides risk reduction, other possible risk mitigation strategies may include (1) avoiding the risk, either by eliminating it or by detouring it; (2) sharing or transferring the risk, via insurances or outsourcing; and/or (3) retaining the risk, where acceptable, and include it in budget planning.

Risk control should also involve the monitoring and periodical re-evaluation of the effectiveness of the undertaken measures. Choosing which measures to undertake will call for a cost-benefit analysis that also takes social and political consequences into account (Caldeira 2005).

### 3.2.2. Risk index analysis

The risk index method is a risk analysis method that allows for a semi-quantitative appreciation of the risk involved in a given process or structure; it is a ranking method that places a greater responsibility on the designer of the method than on the planner who uses it (Larsson 2000). The simplicity of the method makes it both cost-effective and easily understandable to users not familiarized with the development process (Larsson 2000), which favoured its implementation on diverse fields. Furthermore, semi-quantitative risk assessment was noted to provide a more "consistent and rigorous approach to assessing and comparing risks and risk management strategies" than qualitative assessments, avoiding some of its "greater ambiguities" (FAO/WHO 2009: 37). On the other hand, semi-quantitative risk assessment does not involve the amount of data collection and mathematical skills needed for quantitative risk assessment, and therefore it may be used in areas where exact data is unavailable (FAO/WHO 2009). Also, in the beginning of the 21st century, a report prepared for the European Commission by the French (then) Institute for Nuclear Safety and Protection (IPSN) acknowledged that "numbers and figures do not solve all issues. After the increasing use of quantitative assessments, there is now a trend to moderate this approach by giving more importance to all the qualitative aspects of risk management" (2000: 2).

The fact remains that currently there are not enough information records to allow for a quantitative risk assessment in the field of architectural heritage cleaning and thus a semi-quantitative approach is arguably the best solution to undertake the analysis. Considering the arguments above, the risk index method was chosen to develop the risk analysis of heritage cleaning, with a view to building an (in)compatibility assessment procedure, not unlike the reasoning followed by Larsson (2000) in the development of a fire risk assessment method for multi-storey apartment buildings.

In developing a risk index analysis, the following actions should be undertaken (Caldeira 2005; Larsson 2000):

- definition of the goals of the risk analysis;
- identification and characterization of the factors that may affect the risk;
- selection of the indicators or parameters that will be used to describe each factor;
- ascription of values, or weights, to these factors, according to their impact on the risk under analysis.
- development of a rating system for each factor, e.g. using a Likert-type scale, i.e. an ordinal scale.
- clarification of the rules to obtain (a) partial risk indices and (b) a final risk index, which can then be used for purposes of comparison of different options and/or to define threshold values.

While the simplicity of the risk index method is an important advantage, the subjectivity in choosing the indicators and the loss of potentially important information with the final aggregation of values are possible drawbacks (Caldeira 2005) that should be borne in mind.

Regarding the subjectivity in the choice of indicators, or parameters, a Delphi panel of conservation experts was convened to validate the selection (see Section 3.3 and Chapter 7) and thus assist in dimming this subjectivity. As for the loss of potentially important information due

to the aggregation of values, it is expected that the designed procedure encourages the reporting of the performed assessments, so that information is available for future endeavours.
On the other hand, if the factor rating criteria are not rigidly defined, some subjectivity will also arise from the interpretation that each user makes of these criteria. However, in heritage studies, the proposal of rigid assessment rules is seldom possible (or desirable), given the wide variability of situations that may be encountered.
On this topic, it is worth noting that "The basic principle of risk assessment is to collect as much data as you can, providing that the inclusion of more data may affect the decision being made." (FAO/WHO 2009: 45). Thus, and although some degree of subjectivity may enter the risk assessment, a noteworthy gain in planner awareness is expected from the effort in obtaining and recording the necessary information, similarly to what was verified by Waller (1994).

It should be noted that much of the information needed for decision making in heritage conservation is of a subjective character since, evidently, the focal point of conservation is, or should be, significance, which is an intersubjective concept at best; on the other hand, risk is, by definition, linked to uncertainty. Many proposals for the assessment of conservation products, methods (e.g. Sasse & Snethlage (1997), Delegou et al. (2012)) or interventions (e.g. Sanna, Atzeni & Spanu (2008)) rely on expert discussion for the final decision making, thus stressing the need for intersubjectivity. Regarding how to organize the discussion – how many experts?; which specialties are needed?; which questions are critical? –, no rigid rules may be put forward, as the necessary experts are quite contingent of each specific heritage object and respective context, including stakeholders. However, if the object is not significant enough, there may not be an opportunity to assemble a decision panel and, therefore, the risk-index based procedure presented here will hopefully constitute a helpful tool to frame decision making in such contexts.

### 3.2.3. Risk assessment in built heritage conservation

*In the past, museums isolated artefacts to confirm an authoritarian narrative. Conservation must take care not to become the last bastion of that archaic narrative. In fact, the trend in systematic care of heritage is towards reasonable assessment of damage rate and risks.*

Stefan Michalski (1992)

According to Ashley-Smith (1999), risk assessment and management were firstly suggested in the context of heritage conservation by Norbert Baer (1989). Using diverse examples, Baer highlighted the potential of both risk management and assessment in providing "more objective decision-making procedures for selecting conservation options" (1989: 27), namely in what concerned environmental risks to cultural property, and, particularly, on how to deal with those risks.
In the decades that followed, risk management was progressively developed in heritage conservation, chiefly along two main spheres: the preventive conservation of museum collections (via risk asessments) and the disaster risk management of architectural heritage. In the first sphere, the works of Waller (1994, 1996) and Michalski (2004) were pioneer and largely responsible for risk concepts gaining currency in the conservation field (Ashley-Smith 2001); in the second sphere, albeit "no one agency has managed to establish itself as a central repository specifically for disaster and cultural heritage information" (Lattig 2012: 2), the ICCROM action, including a manual (Stovel 1998), training courses and periodic symposia, undoubtedly remains a chief reference (see next subsection), at least for the built heritage.

Applications of risk management to the development of preventive conservation strategies for single (heritage) buildings still seem to be somewhat incipient, but research is underway. In a recent conference, Brimblecombe (2013) highlighted the importance of regular monitoring for the "strategic management of heritage assets" (2013: 1). The author gives some pointers on the modes of damage that should be assessed, and alerts to the shifts in environmental factors that

require continuous and adapting monitoring so that their impact may be correctly appraised and managed.
The concept of risk assessment was also tentatively applied to built heritage as a support tool for the development of preventive conservation plans, mainly drawing on the study of the environmental impact upon the conservation condition of the object. In the same conference, Becherini et al. (2013) reported the results of the exhaustive monitoring and analysis of the environmental conditions at the Pórtico de la Gloria, in the Santiago de Compostela Cathedral. The undertaking resorted to a multitude of analytical techniques and to the expertise of a multidisciplinary team over a period of two years, in order to precisely ascertain the impact of environmental factors on the conservation condition of the building. From the knowledge gained, the team was able to propose some recommendations to mitigate the impact of the environmental factors found to be the most harmful for the conservation condition of the Pórtico. Albeit not proposing a systematic methodology, the reported work may nevertheless represent a relevant contribution for the future development of environmental risk assessments and/or damage modelling specifically directed at the preventive conservation of single buildings; for the time being, however, no further research on this topic was found.

On the other hand, risk assessment approaches to the conservation of built heritage directed towards environmental damage monitoring at an urban, regional or national scale, are increasingly widespread; attempts to define tools that identify and/or rank intervention priorities based on environmental risk parameters are reported as well. The subsections below briefly describe some of the proposed applications of risk management to built heritage conservation.

### *Disaster risk management for built heritage*

The 2010 revision of the New Zealand Charter states the need of risk assessment for places of cultural heritage value, listing natural disasters (e.g. floods and earthquakes) and human-induced threats (e.g. vandalism, neglect, building and development works) as main risks for the integrity of this value. To complement this risk assessment, and whenever applicable, "a risk mitigation plan, an emergency plan, and/or a protection plan should be prepared, and implemented as far as possible, with reference to a conservation plan." (ICOMOS New Zealand 2010: 8) The UNESCO Intergovernmental Committee for the Protection of the World Cultural and Natural Heritage also "recommends that States Parties include risk preparedness as an element in their World Heritage site management plans and training strategies" (UNESCO 2015: art.118). ICOMOS, in turn, has been publishing 'Heritage at Risk' (H@R) reports since 2000, joined by the 'Cultural Heritage and Natural Disasters – Risk Preparedness and the Limits of Prevention' (AA.VV. 2007) and the 'Tangible Risks, Intangible Opportunities: Long-term Risk Preparedness and Responses for Threats to Cultural Heritage' symposia proceedings (AA.VV. 2012, 2013), both building on lessons learnt by field applications of risk management strategies against natural and human-caused disasters.

The ICCROM document on risk preparedness for World Cultural Heritage (Stovel 1998), endorsed by UNESCO and ICOMOS, acknowledges the destructive weight of occasional catastrophes and continued use, claiming that both need to be managed in a way that minimizes losses. While emphasizing that the shift in the conservation paradigm, from curative to preventive, has been slower for the built heritage than for museum collections and movable goods, it stresses that it is still a desirable shift in that preventive conservation may prove to be more relevant in the protection of heritage than the traditional curative-oriented approach:

> It has come to be understood that this [prevention-focused cultural-heritage-at-risk] framework offers a more holistic outlook than conventional approaches to conservation; an outlook viewing all sources of deterioration as linked in a single continuum, from the daily attrition of use at one extreme, to the cataclysmic losses occasioned by disasters or conflicts at the other. (Stovel 1998: 2)

The principle behind the ICCROM document, that has site managers as its main audience, is to integrate risk strategies for the cultural heritage into already existing disaster-preparedness measures for people and/or general property and/or the environment. This ICCROM manual is less of an orthodox risk management tool than a guidebook to develop and implement risk-preparedness strategies, using the document as a guideline checklist. Within these guidelines, it is recommended that planning in risk-preparedness occurs in three phases: preparedness, response, and recovery.

The *preparedness* phase should depart from the documentation and inventory of the characteristics and condition of the site and aim at (1) reducing the hazard impacts or the hazards themselves; (2) strengthening the risk resistance of the site; (3) implementing systems for detection and warning; and (4) improving the response of site users and emergency-response professionals. The *response* phase will largely depend on the previous planning: there should be a plan supporting response prepared in advance and made available to all those involved; exercise drills and having a conservation team ready to respond are recommended. Finally, the *recovery* phase planning should foresee measures for the mitigation of the hazard impacts; for rebuilding both physical and social structures affected by the hazard; and for monitoring, assessing and enhancing the risk-preparedness measures defined. The effectiveness of this phase is also strongly dependent of the soundness of the previous phases.

The ICCROM document contemplates five categories of risks: fire, earthquakes and related disasters, flooding, armed conflict, and other hazards; this last category includes tsunami, avalanches, land and mudslides and flows, winds or tropical storms, and also human-caused hazards, such as vandalism, inadequate maintenance, industrial pollution or accidents. For each hazard, planning advice is provided, always starting with the list of the major possible hazard consequences, followed by guidelines for developing mitigation strategies, from the preparedness to the recovery phases. In 2010, UNESCO issued 'Managing Disaster Risks for World Heritage' (UNESCO 2010) as a complement to the ICCROM manual, which guides site managers through the development of a Disaster Risk Management (DRM) plan.

According to Lattig, who authored a comprehensive review of documents and initiatives on the disaster risk management for cultural property, this field is still "in its infancy" (2012: 2), despite the efforts of several international organizations, including NGOs. Notably, for the same author, a gap that should be addressed further, both in terms of research and practical implementation, concerns "the differences from site to site in how risks are identified and evaluated", which mirror cultural disparities that will "lead to variances in what levels of damage or deterioration are acceptable" (2012: 71). Also missing are case-study analyses that help to better correlate the impact of preventive measures in the mitigation of consequences from natural disasters, albeit it is generally acknowledged that an holistic site management, e.g. the ones proposed by the Burra Charter and the GCI, may contribute substantially to the dimming of such consequences:

> There is no easy definition to describe where preventive conservation becomes disaster preparedness and vice-versa; this means that many of the precautions available to secure significant sites and their elements from adverse impacts in disaster situations are the same measures which retard the rate of deterioration from less severe agents (erosion, changes in use and value). Comprehensive site management IS the best form of prevention because it includes the basic components of any DRM plan: inventory, assessment, conservation, monitoring, planning (short and long-term). (Lattig 2012: 70)

### *Risk Maps*

Regarding risk assessment applied to architectural heritage outside the scope of emergency preparedness, the first notable example found in the literature stemmed from the Italian Central Institute of Restoration (ICR) in the form of a methodology for the development of risk maps (Baldi et al. 1995), presumably the basis for the *Carta del Rischio* (www.cartadelrischio.it/). These risk maps, Baldi et al. emphasized, "besides enriching our knowledge of the field, [have] an important operational value, since they may be utilized in order to establish priorities within the framework of the so called «planned maintenance»" (1995: 1). 'Planned maintenance' (*conservazione programmata*) was a term coined by Giovanni Urbani, then director of the ICR and mentor of the development of risk maps, who defined it in the following terms:

> One such technique, here termed planned maintenance, is needed that, before addressing single assets, deals with the environment that contains them and from where all of their possible decay causes originate. Its aim is therefore the control of such causes, in order to delay as much as possible the rate of decay processes, by carrying out maintenance treatments appropriate to the different types of materials, simultaneously if necessary. (Urbani, quoted in Lobo de Carvalho 2007: 334)

In devising the methodology to develop these risk maps, Baldi et al. (1995) defined three dimensions of risks that may affect built heritage: 'static-structural', 'environmental-air' and those resulting from 'anthropogenic use'. For each of the three dimensions, components intrinsic ('Vulnerability') and extrinsic ('Dangerousness') to the object should be analysed, with the overall risk corresponding to a function of the Dangerousness and Vulnerability components of the three dimensions of risks (Baldi et al. 1995). It is then a question of building 'damage models' that explain the impact of the different risk factors on the artefact.

For the environmental-air damage function, given the multivariate character of these models and to obviate the difficulties in data collection and the complexity of statistical analysis, the authors use 'loss of thickness' at surface level as their unique damage variable, to be described by a small set of explanatory variables ("the (presumed) causal agents of the damage" (Baldi et al. 1995: 5)) via a static regression (damage) model. The authors lean towards 'Lipfert's model', which relates the loss of thickness in calcareous surfaces with rainfall, using as causal variables: $H^+$ concentration (per litre of rain); rate of $SO_2$ dry deposition; atmospheric concentration of $SO_2$; and amount of rainfall in one year (Baldi et al. 1995). 'Loss (of thickness) classes' ranging from 'mild' to 'severe' could be defined, which would be characterized in terms of the explanatory variables, using Lipfert's model – thus building 'typological profiles' for each class. These profiles could then be used to analyse the effects of both wet and dry deposition on calcareous stones and allow for the scoring of the (environmental-air) Dangerousness depending on the class of damage. The necessary data to estimate the precise parameters and validate the model would be obtained through lab and on site analyses of objects and representative specimens (for the damage variable) and direct and/or indirect environmental measures (for the causal variables). The Vulnerability component would be scored "according to [the materials and structures'] degree of liability to deterioration" (Baldi et al. 1995: 11) considering the assessment of their exposure and history.

As for the static-structural Vulnerability component and anthropogenic-use Vulnerability and Dangerousness components, these were to be assessed via detailed questionnaires that would permit to identify indicators, which would be subjected to "appropriate multivariate statistical analyses" (Baldi et al. 1995: 10) in order to synthesize the score for the said components. The static-structural Vulnerability would be grounded on condition assessments of the different construction elements, cross-referenced with information on the building usage. The anthropogenic-use Vulnerability and Dangerousness, in turn, would reflect gathered information on "1) modes of usage of the location context; 2) modes of usage/fruition of the building; 3) modes of usage/management of the building; 4) ill intentional actions (only as it concerns Vulnerability)" (Baldi et al. 1995: 10). Indices on the population decline, population density, touristic pressure and theft occurrence were reportedly incorporated into this component (Lobo de Carvalho 2007). Finally, static-structural Dangerousness would be assessed resorting to relevant geophysical data, e.g. seismic or flooding risks, for the concerned region.

The final risk would correspond to a three-dimensional vector incorporating the Vulnerability and Dangerousness components for the three types of risk and allow for (i) the identification of 'high risk zones' and (ii) the determination of 'intervention thresholds', establishing priorities for "conservation, restoration, maintenance" (Baldi et al. 1995: 14). Nevertheless, no evidence was found of these determinations having been achieved.

With no considerations on the perceived value of potential losses, the described methodology seems to find application especially in damage likelihood determinations, lacking the assessment of the consequences component for a complete risk analysis.

More recently, Galán et al. (2013; 2006) proposed a methodology for the environmental risk assessment of built heritage, where three types of hazards[22] – corresponding to the three dimensions of risks proposed by Baldi et al. (1995) – should be identified and parameterized for each given object, allowing for a vulnerability[23] analysis via a 'Vulnerability Matrix'. In the Vulnerability Matrix, the hazards parameterized for that object are cross-referenced with the "building material characteristics, the structural conservation degree and aesthetic properties" (Galán & Aparicio 2013: 1406) and should be rated, using a 3-point scale (or a 10-point scale, in a different example (Galán et al. 2006)), according to "the frequency and weathering degree of the deterioration patterns" (Galán & Aparicio 2013: 1406) observed in the object (by visual inspection). In other words, a "value of deterioration patterns" (Galán & Aparicio 2013: 1407) is assigned to the "material modifications", "building structure" and "visual appearance" (Galán & Aparicio 2013: 1406) of each object (e.g. in permeability or porosity) according to the perceived influence of a hazard upon that specific modification. Finally, a 'Vulnerability Index' is obtained corresponding to the sum of the ratings as a percentage of the maximum 'value of deterioration patterns' for that object.
However, it is unclear how the matrix should be built: in the proposed matrix, a lot of importance seems to be put on underground water sources, but air temperatures, moisture levels, wind, sun radiation and rainfall, for instance, are (presumably) described in a joint parameter ('weather'). On the other hand, the rating of the different object features according to the hazard parameters presupposes a very clear understanding of how each hazard contributes to each deterioration phenomenon; in the example given, the grounds for the ratings are unclear. Finally, the matrix does not allow for appraising hazards as probabilities; it seems to directly consider their impact upon the objects, which may result confusing when extracting the necessary information for the management of the obtained 'vulnerability' value.

Ortiz et al. (2014), in turn, adapted this Vulnerability Matrix for an environmental impact analysis at urban scale: the authors introduced weathering patterns specifications and further discriminated some of the hazard parameters; moreover, 'vulnerability' and 'hazard' assessments, although defined identically, became independent and more clearly characterized variables. The authors suggested for the vulnerability to be rated with a 6-point scale combining three classes of 'frequency' and four degrees of 'weathering'; similarly, hazards were to be rated according to their 'frequency' and 'intensity' using a 5-point scale, where each point was made to correspond to a range of possible parameter values for the case-study in question, an area in the centre of Merida (Ortiz et al. 2014, tables 2 & 3).
Thus, oppositely to the proposal by Galán et al., 'hazard' and 'vulnerability' are rated independently and the 'Vulnerability Index' becomes a measure of the deterioration condition of each heritage building in relation to its worse possible condition given its deterioration patterns. Moreover, in the example given, the geo-referencing of the heritage structures according to their Vulnerability Indices prompted the authors to affirm that "There is no apparent relationship between vulnerability index and building location" (Ortiz et al. 2014: 437).

Ultimately, hazard and vulnerability ratings are combined for the obtaining of a "specific risk"[24] map. Ortiz et al. resorted to a Delphi panel for the weighting of the different hazard parameters

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[22] Based on the UNDRO 1979 report, Galán & Aparicio define 'hazard' as "the probability that a phenomenon, of an established intensity, may occur in a defined area during a given period of time" (2013: 1405), which does not match the risk management standard application of the term (see Glossary).
[23] Likewise, the authors define 'vulnerability' as "the degree of loss of elements as a consequence of the occurrence of a natural phenomenon of a given intensity" (2013: 1405), which again does not match the standard definition of the term (see Glossary).
[24] According to the UNDRO report definitions, which the authors reference, 'specific risk' is "the expected degree of loss due to a particular natural phenomenon and as a function of both natural hazard

and of the vulnerability according to their perceived roles in the overall risk (Ortiz et al. 2014, fig.1). The reported analysis does not include the identification of consequences[25], and thus it may be inferred that the obtained map assumes an identical value for all the listed buildings and would more appropriately be considered as a mapping of the likelihood of damage occurring.

### *Intervention-prioritizing methodologies*

Other methodologies using risk management tools and approaches have been put forward in recent years for the prioritization of conservation-related endeavours, ultimately intending to identify the urgency of intervening while promoting a more efficient and transparent use of resources.

One of these methodologies used the guidelines stipulated in the ISO 31000:2009 standard for Risk Management, together with fuzzy logic, to develop an 'expert system for predicting buildings service life' applicable to architectural heritage (Ibáñez et al. 2016). For each building, this Fuzzy Buildings Service Life (FBSL) system is fed with information on seventeen identified[26] parameters, grouped under four possible classes of risk factors: vulnerability, static-structural, atmospheric and anthropic; its output corresponds to the expected durability of the object. Because "available knowledge is imprecise or vague and data uncertainty is high, professionals with expertise in this field [were] consulted for their opinion" (Ibáñez et al. 2016: 212) for the risk identification and analysis; furthermore, experts' opinion "was taken into account to estimate the probability of future occurrence of the undesirable event [end of service life]" (Ibáñez et al. 2016: 212) and presumably incorporated in the fuzzification and/or defuzzification rules.

To use the FBSL, multidisciplinarity is a requirement, given that "the risks cover a wide range of causes and consequences (vulnerabilities), including foundations, structures, types of roofing or the geological location of the building in question" (Ibáñez et al. 2016: 211); with one exception, all the parameters are to be rated on an 8-point scale. It should be noted that while the majority of the parameters is related to the likelihood of damage occurring, there are two (anthropic) risk parameters that seem related to the damage consequences[27]: 'heritage value' and 'furniture value'. These are not, incidentally, among the parameters that most decisively influence the durability of a building; those would be the 'conservation [condition]' and 'type of roofing' factors (Ibáñez et al. 2016). On the other hand, it was not possible, from the consulted source, to be clear on how these items play into the final assessment, since the fuzzy rules are not disclosed.

When applied to "architectural sites with homogeneous characteristics" (Ibáñez et al. 2016: 212) the proposed system should allow for a comparison, and thus a prioritization, of the needs for conservative measures. In the example provided, the system was applied to a group of buildings with the exact same scores for 'heritage value' and 'furniture value', which basically means that the final ranking only considered parameters affecting the likelihood of damage. Therefore, and although FBSL seems to incorporate damage consequences, i.e. value losses, into the assessment, the required site homogeneity might very well signify that consequence impact is not yet satisfactorily integrated into the system.

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and vulnerability." (UNDRO 1979: 5) This type of risk, as defined, and analogously to the one used in the *Carta del Rischio*, does not include consequence analysis.

[25] The consequences are termed 'elements at risk' in the UNDRO report where the authors borrowed their definitions from, which correspond to "the population, buildings and civil engineering works, economic activities, public services, utilities and infrastructure, etc... at risk in a given area." (UNDRO 1979: 5)

[26] Via the review of selected literature; parameters were subsequently "validated and ranked by a group of experts" (Ibáñez et al. 2016: 217).

[27] Even though the term 'consequences' seems to be interpreted as 'vulnerabilities' by the authors: "Consequence analysis controls in the FBSL model are considered to be inherent vulnerability factors of the building" (Ibáñez et al. 2016: 212).

Yet another proposal for the establishing of conservation (research) priorities based on environmental risks was made by Gizzi (2008), who developed a methodology to manage the existing and prospective geological and geotechnical information of heritage sites. The methodology is to proceed in five sequential steps, starting with “a preliminary analysis” of the site and subsequent formulation of hypotheses on “the geological-geotechnical causes of failures in the building foundation soils” (Gizzi 2008: 303); followed by validation or revision via “site surveys and analysis” (Gizzi 2008: 303) and an assessment of the available data and its usefulness (‘completeness analysis’), resorting to a questionnaire (Gizzi 2008: Table 1) and to the evaluation of the ‘Engineering Geological Usefulness Parameter’ (EGUP); lack of information would require the planning of further research.

The proposed questionnaire works as a checklist to investigate the existing information on diverse aspects related to the geological-geotechnical features of the site in question; it also offers a ranking system to assess the quality of the available data, furthermore proposing weights that ultimately allow for the computation of the EGUP as a normalized weighted mean (Gizzi 2008). The obtained parameter is suggested to represent an objective quantification of “the usefulness of available data by identifying the site-specific geological and geotechnical influences that threaten the cultural heritage.” (Gizzi 2008: 307) The EGUP will range between the values of 0 (no available data) and 1 (detailed data available), but “To identify the geological-geotechnical influences, it is necessary to reach at least a value of about 0.5-0.6. However, the value of 0.8 represents the threshold value that should be reached, at least” (Gizzi 2008: 307).

As for the allocation of funds to further investigations, it should be inversely proportional to the EGUP value, at least for “sites with cultural heritage of considerable importance”: “in the sites with lower EGUP, higher resource allocations will be guaranteed for investigations”, although “If only low resources are available, it is more appropriate to complete investigations on a site with a high EGUP, i.e. where a lot of data already exists” (Gizzi 2008: 307). The author also suggests for a national database of EGUP values to be built and constantly updated, allowing not only for a more efficient resource allocation, but also “to assure the posterity of a greater number of cultural heritage sites by taking adequate and conscientious safeguard countermeasures.” (Gizzi 2008: 310)
Given its comprehensiveness, this proposal could represent a step forward in the systematizing of information on the likelihood of occurrence of geological and geotechnical risks, although a complete risk analysis would still need tools for consequence assessment.

### *Project risk management*

It is interesting to note that risk management proposals for built heritage conservation do not stem uniquely from Engineering fields: a Management contribution, to be applied in intervention planning, was also recently put forward in the form of ‘Project risk management for sustainable restoration of immovable cultural heritage’ (Atakul et al. 2014; Thaheem 2014).
Project Risk Management (PRM) is one of the ten ‘knowledge areas’ of Project Management (PM), and consists in the application of risk management concepts and tools within the scope of Project Management[28]. The applicaton of PM and PRM was proposed to support decision

[28] Project Management, as defined by the Project Management Institute (PMI), is a discipline dedicated to “the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements” (PMI 2016); where ‘project’ is described as a “temporary endeavor undertaken to create a unique product, service or result”, meaning that “it has a defined beginning and end in time, and therefore defined scope and resources” and that it “is unique in that it is not a routine operation, but a specific set of operations designed to accomplish a singular goal.” (PMI 2016) The application of Project Management entails going through a well-determined and standardized sequence of ‘processes’, grouped under the headings Initiating – Planning – Executing – Monitoring and Controlling – Closing; using information gained from ten ‘knowledge areas’: Integration; Scope; Time; Cost; Quality; Procurement; Human resources; Communications; Risk management; and Stakeholder management. (PMI 2016)

making when planning architectural heritage restoration projects whereby PM would allow addressing "the intricate nature of restoration projects" (Atakul et al. 2014: 151), whereas PRM would target the risks inherent to restoration interventions; the PM structure within which the PRM framework would be implemented is presented in Table 3.6.

**Table 3.6:** PM structure and PRM actions proposed for the planning of restoration interventions.

| PM Phase | Description | PRM actions |
|---|---|---|
| 'Motivation/ need for restoration' | Intends to ascertain the grounds behind the restoration, calling for a physical analysis of materials and structures; and for an exam of "changes in geophysical and political/statutory conditions" (Thaheem 2014: 149) | Identification of risks to the project, using visual inspections, expert interviewing, brainstorming, Delphi method, site surveying. |
| 'Feasibility' | "aims at establishing the viability of restoration viewed from different perspectives" (Thaheem 2014: 150), including 'Historical/cultural feasibility', which amounts to determining the currency of the object values; 'structural feasibility', to check the ability of the object to withstand a restoration intervention; and 'financial feasibility': the final decision on whether to restore the object or not should be made after this stage. | Assessment of project risks:<br>- further risk identification, using visual inspections, expert interviewing, brainstorming, Delphi method; document reviewing[29]; further site surveying.<br>- risk analysis, with brainstorming.<br>- risk evaluation via probability and impact analysis. |
| 'Design' | Concerns the planning "in terms of materials, structure and restoration technique" (Thaheem 2014: 151) | Assessment of risks related to the 'design' choices, using the same techniques as above. The Delphi method should be used for the final ranking and selection of the most important risks. |
| 'Developmen t' | Corresponds to "regular site work, involving construction and restoration workers and engineers" (Thaheem 2014: 152). | Identification of 'development' risks using "visual analysis, site surveys, non-invasive investigation and [site staff] interviewing"; Risk analysis with "quick brainstorming along with semi-quantitative techniques" (Thaheem 2014: 152-153) |
| 'Closeout' | End of the project. Reporting of results and eventual introduction of a 'monitoring phase'. | Reporting of all the identified risks and the strategies pursued to deal with them. |

The risk management component is stressed by the authors, since

> the restoration activity is a custom-built undertaking for every heritage artifact based on their variety and nature. Generic guidelines are available but fitting with specific conditions, tailor-made actions are inevitable, giving raise to adhocism. As a result, there is always a tremendous amount of uncertainty involved in these projects. Therefore, restoration projects are largely affected by risks. (Atakul et al. 2014: 150)

The suggestion of qualitative or semi-quantitative risk assessment techniques, which the proposed framework postulates as "[sufficing] for the purpose of risk analysis" (Atakul et al. 2014: 155), is suggested because of the supposed scarceness of "risk taxonomies"[30] (Thaheem 2014: 7) in cultural heritage literature, since "the usage of complex quantitative and simulation-based techniques requires a lot of past data" (Atakul et al. 2014: 154), which presently is not retrievable from conservation projects.

The proposed framework was built "on the basis of lessons learnt from [the] construction industry" (Thaheem 2014: 110). This "specialized and customized PM process" (Atakul et al. 2014: 157) is in fact a (slight) adaptation of a framework devised for building Repair &

[29] "Documentation reviews involve reviewing restoration plans, detailed specifications, assumptions, historical information from a total project perspective as well as at the individual deliverables or activities level" (Atakul et al. 2014: 156).

[30] In this context, 'Taxonomy' is defined as "a breakdown of possible risk sources", a tool "which can normally be found in other engineering fields." (Atakul et al. 2014: 153)

Maintenance projects, justified because "building repair projects share a lot of common features with respect to restoration projects." (Thaheem 2014: 129) 'Common features' notwithstanding, it should be noted that the framework is based on project goals that do not necessarily coincide with contemporary international conservation recommendations, as indicated by the definition: "Restoration, preventive or corrective, is carried out in order to reinstate the historic building in as much its original shape as possible. [… i.e.] restoration mainly aims at reconditioning the artifact in its architectural originality" (Thaheem 2014: 142), which shows that the authors do not entirely grasp current conservation trends.

Conceptual differences aside, the partial application of the PRM framework to two case studies, and even though both restoration teams were reportedly receptive to the idea, did not seem to yield too much new information to the projects: the identified risks (e.g. "Availability of knowledge of materials and products used in previous restorations/interventions" (Thaheem 2014: 163) and respective mitigation strategies (e.g. "In order to respond to the risk of unavailability of knowledge, cataloging of previous as-built case studies and analogies is suggested" (Thaheem 2014: 164) are all well-known by conservator-restorers; in fact, in one of the case studies, "the team was [already] doing all that the framework advocates but using different vocabulary." (Thaheem 2014: 176), and thus the proposed framework is apparently still missing the conservation technical knowledge necessary for more in-depth (risk) analyses.

### *3.3. The Delphi Method*

The Delphi Method structures the communication of a group of experts in a way that allows for the group to more effectively tackle a complex problem. Consensus is built within the group of selected experts via their answer to questionnaires that are delivered iteratively, until an agreement is reached. The successive iterations, in which all expert answers are made anonymous and re-submitted to the panel for reassessment along with a new questionnaire, allow for consensus to be reached without group or peer pressure, meaning that all answers are given equal importance (Hsu & Sandford 2007; Linstone & Turoff 2002). The anonymity of the respondents furthermore encourages their expressing of views that may be less consensual or popular, and it eliminates the effect of dominating personalities. Another chief advantage of Delphi lies in its not requiring personal meetings – quite the opposite, it precludes these by definition, allowing for each member of the panel to participate at their convenience, within a given time frame. Delphi is also said to accomplish an "ownership of outcomes"[31] (IEC 2009: 30).
Limitations of Delphi include the time and labour demanded, both for the persons responsible for its application and successive iterations and for the panellists; and the requirement that all participants must be able to articulate their thoughts when writing in the working language (IEC 2009).

The Delphi Method has proved useful in solving problems where the use of analytical data is not possible or feasible and where expert judgment is required, most notably in forecasting, identifying and/or prioritizing issues and developing concepts or frameworks (Okoli & Pawlowski 2004). As a risk assessment technique, the Delphi Method is applicable "at any stage of the risk management process or at any phase of a system life cycle, wherever a consensus of views of experts is needed" (IEC 2009: 29). In the vicinity of the topics approached here, Delphi has been applied, for instance, in identifying management criteria and indicators in sustainable ecotourism development processes (Abidin 1999); and in the development of a fire

[31] This "take on the word 'ownership' is perhaps more readily illustrated by its antonym: if [panel members] 'disown' the elements/emphases [the Delphi exercise] brings, then they refuse to acknowledge or accept them as their own […] or ignore them." (Stoeglehner et al. 2009: 115).

risk index method for multistorey apartment buildings (Karlsson & Larsson 2000; Larsson 2000).
In cultural heritage research, the Delphi Method has been used in supporting valuation techniques (Carson et al. 2013), tourism management decisions (Garrod & Fyall 2000) or, as shown earlier, environmental risk analysis (Ortiz et al. 2014).

The application of risk assessment tools to heritage cleaning allowed for the development of an *incompatibility risk assessment procedure for built heritage cleaning*, which was subjected to expert evaluation using the Delphi Method (see Chapter 7).

### 3.4. Some remarks

While several proposals exist for supporting decisions at national, local and site management levels, and notably the value-based management processes mentioned in Chapter 2, no corresponding number of straightforward tools were found to support decision making at the intervention-planning level for the built heritage. The Eight-Step Planning model and its complementing (In)compatibility Assessment procedure thus represent an important contribution to decision making in conservation, notably in what they bridge the gap between macro-scale site management and micro-scale product choice by offering a comprehensive planning guide to conservation interventions. On the other hand, the use of the (In)compatibility Assessment procedure by different authors in built heritage scientific research permits suggesting that at least some of its indicators, as well as underlying precepts, are accepted by the scientific community dwelling in (built) heritage conservation.

Nevertheless, some improvements may be suggested to these methods. Regarding the Eight-Step Planning model, some suggestions were already made, prompted by a case-study application of the model (Revez et al. 2012); but more steps may be proposed to bring the model closer to the concept of conservation as is viewed today, i.e., as an endeavour aimed at significance protection. Hence, two new actions – significance assessment and the writing of a statement of significance – were further added to the model.
Introducing significance more clearly into the Planning model serves a double purpose: first and foremost, it encourages the planner to gain a more complete insight of what they are trying to protect and/or enhance; furthermore, it permits to define the concept of ‘compatibility’ in a more operative and encompassing way within the scope of both the Planning model and the (In)compatibility Assessment procedure.

Regarding decision making at intervention level, the Assessment procedure was found lacking in what concerns the planning of cleaning interventions. Heritage cleaning is an extremely delicate procedure that could benefit from some directives to guide planners, but no such provision integrated the Assessment. The question then became if such a tool could be developed within the scope of these DSS tools, i.e., stemming from a compatibility-based approach. The definition of compatibility that sustains the (In)compatibility Assessment focuses on preventing ‘damage (technical or aesthetical)’ from befalling the ‘historic material’; and on the ‘durability’ of the intervention. This definition is replaced herein by the one given in Section 2.2.6, which was found to be more inclusive and more operative because of contemplating the possibility of different types of damage (other than technical or aesthetical), while still considering the long run implicit on the term ‘durability’. Thus, ‘compatibility’ became ‘*the extent to which a product, method or action may be used upon a heritage object without putting its present or future significance at risk.*’ Accordingly, resorting to a risk assessment approach was a logical step, since a systematic analysis was needed to rigorously ascertain the meanings of ‘damage’ and ‘risk’ vis-à-vis heritage significance and, from there, propose a means to evaluate the ‘extent’. This work is described in the next chapters.

Typically, contributions using risk management for the conservation of built heritage will focus on disaster preparedness or assist decision making especially within the scope of risk mapping and/or prioritization of interventions, although applications supporting monitoring and maintenance are beginning to emerge. Nonetheless, these methodologies do not seem to configure a complete built heritage risk assessment due to lacking the integration of consequence evaluations – and "it is important to have clear ideas about values and their relative weight before attempting to evaluate risks and certainly before deciding about future interventions" (Smars et al. 2012: 120). On the other hand, no examples of the application of a risk assessment methodology to actual conservation actions/interventions (neither for movable nor for immovable heritage) were found in the surveyed literature.
For movable heritage, using risk management has permitted significant developments in the field of preventive conservation, including the documentation, inventory and monitoring areas (see, for example, Ashley-Smith 1999; Cane et al. 2011; Michalski 2008; Waller 1996). Yet, a literature survey of research on the risk management of museum collections, which has been more consistently applied to actual cases than that on immovable heritage, yielded no findings of risk management focusing on conservation and/or restoration actions. This may be due to the still relative newness of the application of risk management to heritage conservation, or to the broadness of aspects involved in a conservation intervention and consequent difficulties in the systematization of the necessary assessments, or a combination of both. In theory, however, it seems reasonable that an approach aimed at minimizing risk would be applicable to the highly risky activity of intervening upon heritage objects; in any case, no elements were found to dismiss the application of risk assessment to the planning and execution of conservation interventions.

Given the previously highlighted potential benefits of applying risk assessment tools and concepts, the analysis presented below intends to constitute a reference step in this direction for conservation interventions, with the ultimate aim of assisting decision making – which is, after all, the "purpose of calculating risk" (Ashley-Smith 1999: 129).

# 4. Built heritage cleaning interventions

*"Good" decisions are the result of careful planning.*
M. Demas (2002)

Heritage cleaning becomes necessary whenever deposits hinder the significance of the object, particularly when they promote the degradation of its immaterial or material features, or when the authenticity and/or integrity of the object are threatened. Cleaning may also be required to assess the condition of the object or when preparing surfaces to receive consolidation and/or other protective treatments (Ashurst, J. 1990; Doehne & Price 2010; Lazzarini & Laurenzi Tabasso 1986). Often, cleaning will be the most visible – and thus scrutinized (Torraca 1995) – result of a conservation intervention.
Cleaning operations may seem deceptively straightforward, but they are potentially harmful and always irreversible interventions and therefore adequate planning is crucial to achieve satisfactory results (Delgado Rodrigues et al. 1997; Lazzarini & Laurenzi Tabasso 1986). However, planning is made extremely complex by the (practically) endless combinations of substrates, deposits, interaction between them, environmental conditions and intended cleaning levels that may occur. The goal of this chapter is to analyse the grounds and conditionings that must be considered when planning cleaning interventions upon built heritage objects with no polychromy.

Essentially, it is considered that, as a heritage conservation action, cleaning should maintain or enhance the significance of the object while respecting its authenticity and integrity; therefore, any cleaning action must be compatible with this significance, authenticity and integrity.
Compatibility is a widely accepted conservation principle that has been used to guide decision making in different conservation contexts (see Table 2.9), although it has not yet been specifically applied to cleaning.
This section begins with the highlighting of the issues that must be tackled by a heritage cleaning intervention, and suggests a flowchart for the planning process.

## *4.1. Built heritage cleaning*

### 4.1.1. Defining goals

First and foremost, the cleaning of a heritage artefact, like any intervention directed towards heritage conservation, aims at preserving or enhancing the significance of the artefact, while respecting its authenticity and integrity. Therefore, regardless of whether the cleaning intervention is part of a larger conservation programme or a standalone procedure, its first

planning step should be to carefully assess this significance, so that the conservation objectives, priorities and constraints may be defined.
As seen in Chapter 2, many value systems and assessment techniques may aid in this part of the process, depending on the human and time resources available; the complexity of the assessment should match the perceived significance of the object, the magnitude of the planned intervention and/or the dimension of the social group for whom the object is important. This significance analysis should consult the group of stakeholders and, even if just tentatively, outline value priorities; ideally, assessments of integrity and authenticity should also be performed.

From the significance assessment, it is possible to analyse the actual necessity of cleaning: this implies considering the deposits and assessing their current or potential harmfulness to the significance, authenticity and/or integrity of the heritage object; even if no incompatibilities are found, cleaning may nevertheless be necessary to assess the condition of the object more precisely, or before other treatments are carried out. Deciding on the necessity of cleaning must be made on a case-by-case basis, and the only rule that may be stated at this point is that, as with all conservation actions, the planner needs to balance the actual or potential impacts of undertaking the intervention or not on the significance of the object. It is by no means an easy endeavour, as pointed out by Salvadori & Charola regarding biocolonization: "it is fundamental to be able to determine when biocolonization is desirable and does not pose a problem, when it is merely an aesthetic issue, and when it is a serious deterioration factor. This is probably the most difficult task yet to be solved" (2011: 48).
On this topic, the Victoria & Albert Museum Conservation Department published an 'Ethics Checklist' (V&AMCD 2004) as a list of questions that lead the user to carefully consider the implications – ethical and practical – of any given conservation decision. Specifically for built heritage cleaning, Andrew et al. proposed a checklist of "aesthetic considerations"[32] (Andrew et al. 1994: 44), meant to be applied prior to cleaning decision making. Any object of aesthetic value (or integrating an ensemble valued on aesthetic grounds) would benefit from a thorough pondering of the questions proposed by this checklist, providing that it is integrated in a more encompassing assessment that includes the remainder of the values embodied in the object.
Appelbaum's concept of 'ideal state' may prove helpful at this point:

> The ideal state is the physical state […] that best embodies the object's values. […] It is not intrinsic to the object, but depends on present ownership, use, and meaning, and its projected future. […] Identifying an object's ideal state clarifies its meaning and helps to shape its treatment whether or not, for technical or practical reasons, a treatment can re-create the ideal state exactly. (2010: 173)

The flowchart in Figure 4.1 proposes a sequence for the general decision-making frame of a heritage cleaning intervention. It is suggested that the necessity for cleaning is evaluated firstly, stemming from a significance assessment. This evaluation should ponder over (1) the actual or potential impact of the different deposits on the assessed significance, authenticity and/or integrity and (2) the future uses planned for the object. From these, it should be possible to define the 'ideal state' of the object, and more easily ascertain which conservation methods will help to attain it.

[32] In the 1990s, aesthetical grounds were still verified to be the most common incentive to undertake cleaning interventions (Ashurst, J. 1990; Biscontin, Zendri, Bakolas, Longega, et al. 1995).

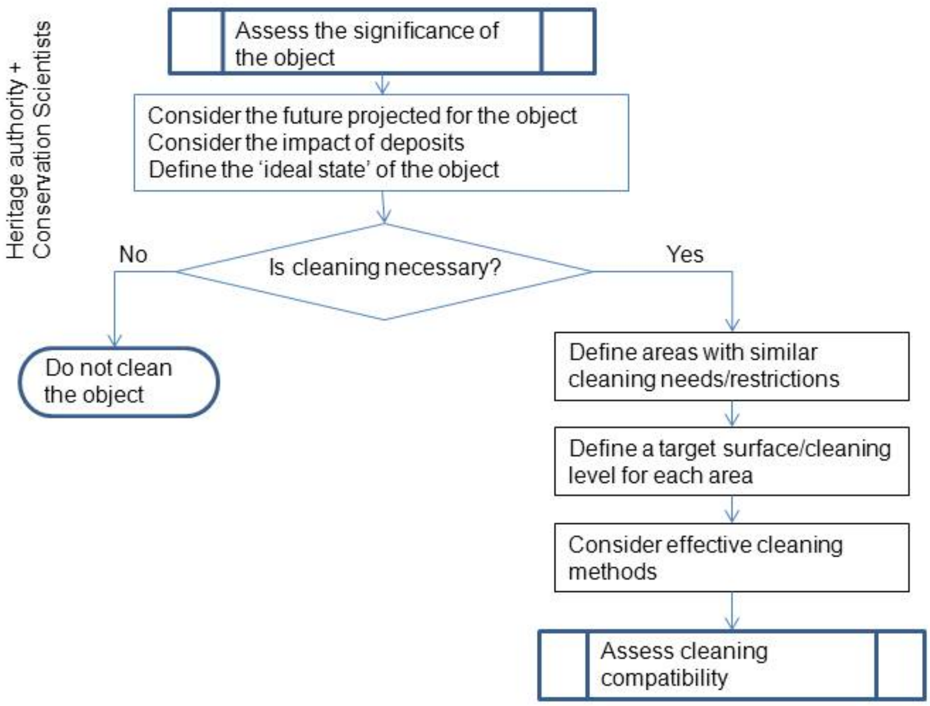


**Figure 4.1:** General cleaning decisions flowchart proposal. It is for the heritage authorities, together with conservation scientists, to assess significance and, from there, evaluate the actual need for cleaning. Cleaning should only be undertaken if considered compatible with the significance of the object.

If it is decided that the object does need cleaning, then the next step is to define areas of similar cleaning needs and/or restrictions. This amounts to grouping areas that are homogenous in terms of relevance and surface condition, i.e., areas of similar significance (e.g. a decorated portal will not contribute to significance in the same manner a plain wall does); with similar deposits (for example, a black crust and a graffiti will pose different cleaning problems); and with similar surface conditions (given that cleaning a surface with active material loss is evidently different from cleaning a sound surface).

For each defined area, the most compatible target surface, i.e., the cleaning level that better serves the overall significance of the object will have to be defined. Specific cleaning objectives must be judiciously defined and justified, also considering the future uses planned for the object, since the choices made at this stage will have a very relevant impact on its future significance. It cannot be overstressed that "even if the conservation needs of the architectural surfaces are strong and entail the need for cleaning, this does not automatically determine the appearance that the façade material will assume after the restoration. The image of the [historic] monument largely depends on initial project choices, on choices made during the restoration and finally on the skill of the operators." (Torraca 1995: 5)

Defining a target surface means, firstly, analysing which materials are "in the wrong place" (Moncrieff & Weaver 1992: 13), justifying and recording the decision and, secondly, considering which methods will effectively remove them; this removal may then be assessed in terms of compatibility, resorting to the procedure proposed below. If no cleaning method is deemed compatible, then an alternate target surface should be defined, along with the corresponding effective methods, and reassessed, until the most compatible cleaning level/cleaning method is identified.

In other words, and rearranging the sequence of questions suggested by Moncrieff & Weaver, it is necessary to analyse: (i) "Why clean?" (ii) "What will be the effect of cleaning?" (iii) "How can you clean the object?" and (iv) "Can the object tolerate being cleaned?" (1992: 16).

### 4.1.2. Selecting cleaning methods: effectiveness and harmfulness

Considering the undesirable deposits should permit to identify which methods will effectively remove them, as well as to define more precisely the intended cleaning level. Table 4.1 non-exhaustively lists some methods generally deemed effective for the removal of deposits commonly found in heritage buildings.

**Table 4.1:** Methods reported as effective for the cleaning of built heritage

| Deposits | Prospective cleaning methods/agents |
|---|---|
| Loosely bound particles | • Hand tools (scalpels, brushes, spatulas, rubbers, etc) with or without water (Lazzarini & Laurenzi Tabasso 1986)<br>• Water at very low pressure (<0.35MPa) followed by rinsing at higher pressures (0.65MPa to 2.75MPa), with or without brushing (Slaton & Normandin 2005) |
| Adhered soot | • Hand tools (scalpels, brushes, spatulas, rubbers, etc) with or without water (Lazzarini & Laurenzi Tabasso 1986)<br>• Water poultices using clay (e.g. sepiolite, attapulgite) and/or paper paste (Lazzarini & Laurenzi Tabasso 1986)<br>• Ammonium citrate at low concentrations (~2%) and high pH (>9) (Gervais et al. 2010)<br>• In marbles: agar gel poultices (Gulotta et al. 2014) |
| Black crusts | • Lazzarini & Laurenzi Tabasso (1986) suggest the following methods:<br><u>In low-significance surfaces:</u><br>- Low pressure (0.25MPa-0.4MPa) water jet;<br>- Wet or dry particle jet under controlled pressure (0.05MPa-0.3MPa);<br>- disodium or tetrasodium EDTA poultices;<br>- EDTA + $NaHCO_3$ poultices;<br>- Sodium and ammonium bicarbonate poultices;<br>- Neutral soaps.<br><u>In significant surfaces:</u><br>- Nebulized water (deionized);<br>- "Small and perfectly controllable" tools such as scalpels, spatulas, micro-drills with different burrs, dentistry instruments, etc.<br>- Ultra sounds (only in sound substrates) as a complement of nebulized water;<br>- Micro-particle jet (with pre-consolidation if necessary);<br>- Poultices: AB57® (a water solution formulated with 3% $NH_4HCO_3$; 5% $NaHCO_3$; 2.5% disodium EDTA; 1% Desogen®; 6% CMC (%w/w)); with special clays; 'biological' poultices: containing a urea and glycerine water solution that interact with nitrobacteria in the crust; etc.<br>- Laser.<br>• Snethlage (2011) furthermore mentions ion-exchange resin poultices. Matteini et al. (1995) specify that cationic resins promote an increase in acidity and therefore cannot be applied on carbonate stones; the authors also suggest their use in combination with ammonium carbonate, to enhance effectiveness. A 5:1 mix of strong anionic and weak cationic resins, applied as poultices with cellulosic additives is reported to be effective on marbles (Guidetti & Uminski 2000).<br>• Toniolo, Cappitelli, et al. (2008) recommend the sulphate-reducing bacterium *Desulfovibrio vulgaris*, following research firstly reported by Gauri & Chowdhury (1988).<br>• Lanterna & Matteini (2000) suggest laser in combination with ammonium carbonate or ion-exchange resins.<br>• Valentini et al. (2012) reported good results using carbon nanofibers dispersed in a non-ionic surfactant and enzymatic cleaning with glucose oxidase and lipase.<br>N.B.: Because its selectivity for calcium is higher than for gypsum, di-sodium EDTA should not be used as sole solute for gypsum removal (Thorn 1993). |
| Biological colonization | • Higher plants: triazine compounds (Lazzarini & Laurenzi Tabasso 1986);<br>• Algae: quaternary ammonium salts or copper compounds (Aires-Barros 2001) (Lazzarini & Laurenzi Tabasso 1986) |

| | |
|---|---|
| | • Moss and lichens: mechanical cleaning complemented with biocides (Lazzarini & Laurenzi Tabasso 1986)<br>• Dried algal and cyanobacterial crusts: hand tools and/or micro-particle jet (Snethlage & Sterflinger 2011)<br>• Dark pigmentation remaining after biocidal treatment: a commercially available mixture of toluene, dimethyl dialkyl quaternary ammonium hydroxide and methanol (Delgado Rodrigues & Valero 2003)<br>• Photosynthetic microorganisms, fungi and lichens: leave-in products with pyridine derivatives (Salvadori & Charola 2011)<br>• Bacteria, algae and fungi: biocides combined with photodynamic therapy (Alakomi et al. 2006) and/or permeabilizing agents and/or pigment inhibitors (Salvadori & Charola 2011);<br>• Algae and fungi: titanium dioxide under UV light (Salvadori & Charola 2011);<br>• UV radiation (Villegas Sánchez et al. 2003);<br>• Laser, alone (Siano et al. 2012) or combined with microwave heating (Mascalchi et al. 2015)<br>Salvadori & Charola (2011) draw attention to the fact that the efficacy and durability of the biocidal treatment will critically depend, inter alia, on the porosity and mineralogical composition of the substrate. |
| Iron stains | • Ammonium phosphate ($(NH_4)_3PO_4$) or diammonium hydrogen phosphate $[(NH_4)_2HPO_4]$ with a $7<pH<8$ achieved by adding phosphoric acid (Aires-Barros 2001; Fassina 1993; Lazzarini & Laurenzi Tabasso 1986);<br>• Ammonium bifluoride ($NH_4HF_2$) 1% to 5% in water (precautions necessary near ceramics) (Lazzarini & Laurenzi Tabasso 1986)<br>• Moistened potassium oxalate applied as a paste (Fassina 1993; Stambolov 1971)<br>• EDTA poultices (Lazzarini & Laurenzi Tabasso 1986)<br>• Ammonium citrate and glycerine in attapulgite poultices (Ashurst, J. 1990)<br>• Ammonium thyoglicolate (i.e., thioglycollic acid buffered with ammonium carbonate; precautions are necessary for surfaces containing gypsum and/or iron that are not intended for removal) (Gervais et al. 2010; Thorn 2005)<br>• For carbonate stones: ammonium citrate at low concentrations and high pH (>9) (Gervais et al. 2010); sodium dithionite ($Na_2S_2O_4$) (Stambolov 1968); sodium dithionite:tri-ammonium citrate buffered solution (Vella et al. 2008)<br>It is generally recommended that the agents are applied in poultices (Lazzarini & Laurenzi Tabasso 1986)<br>N.B.: Given its comparatively lower solubilizing ability for calcite, tetra-sodium EDTA should be preferred to di-sodium EDTA in iron-stain removal; caution is nevertheless recommended for both compounds (Thorn 1993). |
| Copper stains | • 10% sulfamic acid ($NH_2SO_3H$) in aqueous solution, applied in a poultice with thixotropic substances such as clay or CMC (Fassina 1993; Lazzarini & Laurenzi Tabasso 1986; Stambolov 1971)<br>• 2-10% ammonium carbonate ($(NH_4)_2CO_3$) (Fassina 1993) or up to 20% ammonium carbonate (Lazzarini & Laurenzi Tabasso 1986; Stambolov 1971) in aqueous solution, applied in poultices.<br>• Ammonium chloride and clay poultice (1:4) prepared with a 10% ammonia water solution (Ashurst, J. 1990)<br>• EDTA poultices (Lazzarini & Laurenzi Tabasso 1986) |
| Calcite concretions | • Ion-exchange resins as poultices (Lazzarini & Laurenzi Tabasso 1986)<br>• Di-sodium EDTA (Thorn 1993) |
| Hydrophobic substances | • Aromatic or aliphatic solvents, e.g. toluene or acetone (Fassina 1993) that may be applied as gels or in poultices (Villegas Sánchez et al. 2003)<br>• Alkaline solvents, e.g. amines (Lazzarini & Laurenzi Tabasso 1986; Malaga & Bengtsson 2008)<br>• Sodium hexametaphosphate $(NaPO_3)_6$ and methyl esters (Malaga & Bengtsson 2008) |
| Graffiti | • Aliphatic solvents (Lazzarini & Laurenzi Tabasso 1986)<br>• Laser (Chapman 2000; Sanmartín et al. 2014; Siano et al. 2012) |

| | |
|---|---|
| | • Poultices with: (1) water (with or without neutral or non-ionic surfactants or ammonia); or (2) organic solvents and/or paint removers; or (3) weakly alkaline compounds. (Sanmartín et al. 2014; Weaver 1995)<br>• Micro-particle jets at low pressures (~0.25MPa), under controlled conditions (Sanmartín et al. 2014; Weaver 1995) |
| Soluble salts | • A comprehensive review of desalination poultices may be found in (Vergès-Belmin & Siedel 2005); poultices containing clay seem to be the most efficient.<br>• Lazzarini & Laurenzi Tabasso (1986) recommend clay poultices with deionized water, preceded by soft brushing of efflorescences; Bourguignon et al.(2008) argue that in spite of their good capillary suction and adhesion properties, clays should be mixed with cellulose fibres, to enhance water retention, a result also verified by Gerrow et al. (2014). Ensuring a low poultice drying rate is essential (Bourguignon et al. 2008) (Doehne et al. 2008).<br>• Electrophoresis is also recommended, using, as contact materials, (1) for limestone, a calcite/cellulose mixture (De Clercq et al. 2014); (2) for sandstone, a calcite/kaolin mixture (Ottosen et al. 2014); and (3), for granite, kaolin (Feijoo et al. 2013).<br>• In marbles: agar gel poultices (Gulotta et al. 2014) |

Assessing the effectiveness of the method, as well as setting its operational parameters, needs a case-by-case analysis and usually demands testing, generally in secluded on-site test areas. Visual and tactile assessments are generally a good form of judging on the efficacy of the cleaning method[33], although, given the inherent subjectivity of visual assessments, interdisciplinary discussion is strongly advised (Lazzarini & Laurenzi Tabasso 1986; Vergès-Belmin 1996). Depending on the type of deposit and on the cleaning methods, many other assessment techniques exist, both on site and in the lab. For comprehensive reviews, see Vergès-Belmin (1996) and Laurenzi Tabasso & Simon (2006), who additionally suggest which analytical techniques should assist cleaning method assessment programmes (see below).

Method effectiveness notwithstanding, the three general sine qua non criteria for choosing a stone cleaning process proposed by Lazzarini & Laurenzi Tabasso focus on its non-harmfulness (1986: 107):

- "[the cleaning process/method] should be controllable in each and every stage, graduate and selective";
- "it should not generate materials that are harmful to the conservation of the stone";
- "it should not generate modifications, micro-fractures or strong abrasions to the cleaned surface, that can lead to accelerating deterioration, through the increase of superficial porosity."

To these, Fassina added the need of preserving the "noble patina" (1993: 127) and the original material, and even eventual remnants of previous treatments. Lazzarini & Laurenzi Tabasso also warn against the dangers of over-cleaning in questionable searches for the original material; and against those of under-cleaning, which may result in leaving harmful deposits behind. Cleaning levels must be "«reasoned», balanced and agreed upon not only by those whom best understand the works of art, and their significance and contexts, but also by the experts of materials science" (Lazzarini & Laurenzi Tabasso 1986: 109).
Additionally, attention is drawn to the importance of the skills, knowledge and sensitivity of the cleaning operator, upon which the success of the cleaning process will largely rely (Ashurst, J. 1990; Fassina 1993; Lazzarini & Laurenzi Tabasso 1986; Vergès-Belmin 1996).

[33] Vergès-Belmin considered visual inspection to be a "good tool" and "the simplest method of evaluation [of cleaned areas]" (1996: 70). For surface roughness assessments of abrasive-cleaned stone, visual and tactile evaluations were reported to be the "more practical and cost-effective technique" (Grissom, Charola, and Wachowiak quoted by Doehne & Price (2010: 5)).

### 4.1.3. Selecting cleaning methods: state of the art

In the past decades, different researchers have attempted to put forward more systematic approaches to the evaluation of built heritage cleaning methods, even if "Cleaning is, among the conservation phases, the least frequently documented in the scientific bibliography" (Mecchi et al. 2008: 426). In general, these proposals cover both the effectiveness and the harmfulness of the methods, often not clearly categorized (Mecchi et al. 2008), although some research is devoted to either effectiveness or harmfulness assessments alone. Because the focal point of this research is compatibility, proposals dealing exclusively with effectiveness evaluations are not mentioned here. A compilation of the most exhaustive assessment-system proposals found in the literature may be consulted in Appendix C.

In a dedicated congress held in Bressanone, Biscontin et al. (1995) asserted that heritage cleaning should be undertaken, first and foremost, for the stabilization of the superficial matter of the object, nevertheless respecting and minding the aesthetical values at stake. For the authors, this "fundamental choice that establishes the centrality of the matter" (Biscontin, Zendri, Bakolas, Longega, et al. 1995: 627) would allow for objective method evaluation parameters to be derived, along with their respective acceptability thresholds. This task is, however, not a straightforward one, since most, if not all, of the consulted authors, albeit centring cleaning assessments around the matter of the object, still experience several difficulties[34], including:

i. choosing which specific parameters to test and how to test them;
ii. agreeing on which parameters are of critical testing;
iii. what should be used as reference;
iv. defining acceptability and/or tolerability thresholds for those parameters.

More specifically, within each listed item, the following complexities were identified:

i. <u>choosing which specific parameters to test and how to test them</u>

Vergès-Belmin (1996) reviewed the literature on heritage cleaning research, analysing the most used assessment techniques, both in the lab and on site, which allowed her to propose an extensive evaluation protocol (1996, Fig. 12). However, and even though the author underlines that not all analytical techniques should be selected in every case, there is little guidance on how to select them and on which ones are critical. Vergès-Belmin furthermore remarks that operator skills and "the proper definition of cleaning [equipment] parameters" (1996: 79) are decisive aspects not contemplated in the classification proposal.
Similarly, Hauff et al. (2008) suggest an assessment system heavily built upon non-destructive testing techniques that may be used on site, but highlight nonetheless that the quality of the execution team will have more impact on the final outcome than the method assessment. Nicola Ashurst goes as far as to assert that "more than 75 per cent of the success of a cleaning operation depends on those executing it on site" (1994a: 3).

Although not explicitly proposing a testing protocol, nor criteria or guidelines for decision making, several researchers have made lab or on-site comparisons of the harmfulness of different cleaning methods using different analytical techniques. In these comparisons, the assessment of surface features, including texture, morphology and/or roughness, is recurrent, resorting to visual inspections, but also to sample observations under SEM and/or OM (Fratini et al. 1995) (Álvarez de Buergo et al. 2013) (Ďoubal 2014) and/or stereoscopic magnifying glasses (Iglesias et al. 2006); under petrographic microscope (Pavia Santamaria et al. 1996); or, still, with FOM and LP (Delegou et al. 2008). The analysis may be complemented by coupling the SEM with EDS microanalysis (Villegas Sánchez 2003) or by on-site testing, with inspections via macrophotography and portable microscopes (Iglesias-Campos et al. 2015). Gaspar et al. (2003) used white light interferometry to determine damage thresholds for different methods in different substrates, based on topographical analyses, and Esbert et

[34] As may be concluded from the table in Appendix C.

al.(2003) proposed a similar method for the determination of laser ablation thresholds, based on morphological evaluations under SEM. The preference of researchers for techniques of surface analysis in cleaning evaluations, particularly SEM observations, was also noted by Mecchi et al. (2008).
Besides roughness and/or morphology assessed via microscopy techniques, some authors additionally include water absorption (Alessandrini et al. 1995) or contact angle (Biscontin, Zendri, Bakolas, Polloni, et al. 1995) determinations; or, still, colour measurements (Delegou et al. 2008). If assessing solely chemical methods, and namely biocides, colour measurements may be deemed sufficient for harmfulness assessment (Quaresima et al. 1995), although some authors additionally recommend capillary water absorption and ageing tests, along with SEM observation after impregnation (Villegas Sánchez et al. 2003).

ii. agreeing on which parameters are of critical testing

Based on a literature review on the evaluation of cleaning methods, Mecchi et al. (2008) concluded that no unified approach exists, and proposed that standards should be designed to support an evaluation in two parallel panels – “Guidelines to evaluate cleaning methods” (2008: 430) (Panel A) and “Evaluation of a specific cleaning method in a real case” (2008: 430) (Panel B), to be conducted in the lab and on-site, respectively. The Italian standard UNI 11187:2006 (for the assessment of laser cleaning) is indicated as a model of the documents that would integrate Panel B, but no other directives were listed. A multidisciplinary board, charged with evaluating the methods and defining their requirements, would accompany the entire procedure.

As Grimmer has put it, “The greatest problem in developing practical guidelines for cleaning any historic building is the large number of variable and unpredictable factors involved. Because these variables make each cleaning project unique, it is difficult to establish specific standards at this time.” (1979: 3) – to which Nicola Ashurst added “In fact, it would be unwise and dangerous to establish them.” (1994b: 2)
Nevertheless, reference should be made to the code of practice published by the British Standards Institution (BSI) for the cleaning of buildings (BSI 2000), a collection of recommendations to assist in the cleaning of masonry buildings in general, including, though not limited to, heritage buildings. It is structured similarly to other cleaning guidelines or manuals, such as the ones published by Historic Scotland (e.g. Andrew et al. 1994; Urquhart et al. 1997; Webster et al. 1991) or the National Park Service (e.g. Grimmer 1979; Mack & Grimmer 2000; Weaver 1995), and it does not present specifications, neither for the type of tests to be performed nor for the final cleaning results. Still, the most cited source in the consulted literature on heritage cleaning indisputably remains *Il Restauro della Pietra*, the 1986 guidebook by Lazzarini & Laurenzi Tabasso.

In 2006, Laurenzi Tabasso & Simon authored a comprehensive review on the topic of assessment criteria for heritage conservation (technical) actions, including cleaning. Having remarked on the absence of international standards for these assessments, the authors suggested that the “comparison of the relevant bibliographic references suggests that a good level of agreement among laboratories has been reached concerning the parameters to measure” (2006: 72).
Thus, and although there is not exactly a consensus, the following parameters are generally deemed important in cleaning harmfulness evaluations by most of the consulted authors: visual appearance, surface morphology, and notably roughness features, colour and, to a lesser extent, water absorption and water vapour behaviours. Testing methods also vary, but colorimeters, SEM analyses and standard water absorption and water vapour testing are the most frequently mentioned.

iii. what should be used as reference in comparison assessments

Regarding reference surfaces, most authors suggest comparisons with the surface before cleaning; one exception to this rule is recommended by Sasse & Snethlage (1997), who propose that the results be referred to the "unweathered stone, […] measured on the back side of sufficiently deep drill cores from the object or on freshly quarried stone samples" (1997: 226). Another exception was proposed by Laurenzi Tabasso & Simon (2006), who suggest that the evaluation of some cleaning parameters should juxtapose the results of the cleaned surface against those of the "weathered but not sooted stone" (2006: 75).

Delgado Rodrigues et al. (1997) take the concept of reference surface one step further, advising that the entire process of planning and executing a heritage cleaning intervention should be based on the use of a reference surface, obtained after cleaning trials and duly parameterized and agreed upon by all the actors involved. Such a process would grant a clearer definition of guiding principles and/or specifications, as well as promote a more efficient communication between authorities, consultants and contractors – one of the aspects that Laurenzi Tabasso & Simon (2006) also identified as key in heritage cleaning.

iv. defining requirements, acceptability or tolerability thresholds for the tested parameters

In the aforementioned Bressanone congress, Alessandrini et al. (1995) reported that the sensitivity of their chosen analytical techniques regarding the effects of cleaning was dependent on the mineralogical-petrographic and/or physical characteristics of the substrates. Furthermore, even where the analysis adequately discriminated these effects, the authors were left with the question of how to translate 'harmfulness' into quantifiable numerical terms and, from there, how to specify 'acceptability limits'; or, in other words, what or how much should be considered 'harm' (Alessandrini et al. 1995).

In subsequent years, many authors attempted to tackle subjectivity when assessing cleaning methods, but proposals including (more or less) objective requirements are scarce; the table below lists the few examples found in a literature review.

**Table 4.2:** Requirements for the selection of built heritage cleaning methods.

| Parameter | Requirement | Reference | What? | Who judges? |
|---|---|---|---|---|
| General | "[methods] that do not promote the stability of the fabric, i.e., that degrade the materials, directly or potentially, for example by augmenting the specific surface and consequently its reactivity, **should be excluded**" (Biscontin, Zendri, Bakolas, Longega, et al. 1995: 627) | – | Harmfulness | – |
| | Comparative analysis of four indices:<br>$I_R$: masonry resistance to damage<br>$I_T$: soiling tenacity (cleaning difficulty)<br>$I_S$: severity of the method (damage potential)<br>$I_C$: cleaning ability of the method<br>Cleaning method selection should obey the following: "Select $I_C$ based on $I_T$ such as $I_S$ does not exceed $I_R$" (Spry, cited in Ashurst, N. 1994a: 5) | – | Efficacy and Harmfulness | Planner |
| Visual appearance | To be defined case-by-case (Sasse & Snethlage 1997) | – | Efficacy and Harmfulness | Expert panel |
| | Pre-selection requirement: only methods obtaining a "cleaning degree 2" ("slightly visible patina") and a "homogeneity degree 1" ("homogenous") (Hauff et al. 2008) | surface before cleaning | Efficacy | Expert panel including all the relevant intervention actors |
| | no increase in micro-fractures and other surface discontinuities. (Laurenzi Tabasso & Simon 2006) | surface before cleaning | Harmfulness | Conservation - scientists |
| Rough-ness | Similar average values after treatment (Sasse & Snethlage 1997) | unweathered stone(1) | Harmfulness | Conservation - scientists |

| | | | | |
|---|---|---|---|---|
| | no increase in roughness, micro-fractures and other surface discontinuities (Laurenzi Tabasso & Simon 2006) | surface before cleaning | Harmfulness | Conservation - scientists |
| Water uptake/ absorption | Similar average values after treatment (Sasse & Snethlage 1997) | unweathered stone(1) | Harmfulness | Conservation - scientists |
| | No increase in absorbed water (Laurenzi Tabasso & Simon 2006) | weathered but not sooted stone | Harmfulness | Conservation - scientists |
| | A value increase is desirable (Ďoubal 2014) | uncleaned sample | ? | Conservation - scientists |
| Water vapour transfers | Similar average values after treatment (Sasse & Snethlage 1997) | unweathered stone(1) | Harmfulness | Conservation - scientists |
| | No variation of permeability (Laurenzi Tabasso & Simon 2006) | weathered but not sooted stone | Harmfulness | Conservation - scientists |
| Colour | ΔE≤3 within one ashlar (Sasse & Snethlage 1997) | – | Harmfulness | Conservation - scientists |
| | criteria to be defined case-by-case (Tabasso&Simon) | – | – | – |
| SEM/OM observa-tion | no increase in micro-fractures and other surface discontinuities (Laurenzi Tabasso & Simon 2006) | surface before cleaning | Harmfulness | Conservation - scientists |
| Salt profile | strong reduction of salt content (Laurenzi Tabasso & Simon 2006) | surface before cleaning | Efficacy and Harmfulness | Conservation - scientists |
| Reference surface | Agreement on a cleaning degree as prepared on a trial area (Sasse & Snethlage 1997) | – | – | "all parties involved" (Sasse & Snethlage 1997: 234) |
| | Agreement with reference surface in terms of visual appearance and verification of (pre-selected) reference parameters: colour; roughness and, for water-based methods, salt content (Delgado Rodrigues et al. 1997) | Characterized pre-defined reference surface | Efficacy and Harmfulness | Owner, scientific consultants, conservator-restorers (executants) |
| Inspection after "several months" | Inspection of possible deleterious effects of water or chemical cleaning, such as salt efflorescences, stains or colonization by algae. (Vergès-Belmin 1996) | – | Delayed harmfulness | Conservation-scientist |

Notes:
(1) "measured on the back side of sufficiently deep drill cores from the object or on freshly quarried stone samples" (Sasse & Snethlage 1997: 226)

It should be noted that a team lead by Moropoulou & Delegou (Delegou et al. 2012; Delegou & Moropoulou 2008; Moropoulou et al. 2008) proposed a 'Cleaning Performance Index (CPI)' for the assessment of methods used in the cleaning of black crusts on marble surfaces. The assessment is built upon the evaluation of surface changes, induced by the different cleaning methods, in terms of: chemical and mineralogical composition, texture, roughness, surface fracturing and colour, as measured by SEM/EDS, LP, DIP (of SEM images) and colorimeter. For each cleaning method, a CPI is obtained via the computation of the respective parameter values using 'fuzzy rules' (based on expertise, experimental results in black-crust cleaning of marbles and relevant literature (Delegou et al. 2012)), yielding a numerical value to be labelled "«Not acceptable cleaning», «Medium cleaning», «Acceptable cleaning» and «Recommended cleaning – Optimum»" (Delegou & Moropoulou 2008: 1184). This assessment system was not included in the table above because the criticality and/or influence (weight) of each parameter in the CPI were not specified in any of the consulted sources; not to mention that this CPI is circumscribed to the cleaning of black crusts on marble surfaces.

Mecchi et al. (2008) argue that a "scientific approach" should substitute the current "«common sense» approach" that centres decisions on the opinion of "the board in charge of conservation" (2008: 425). Unfortunately, one could argue that, in many instances, and especially for objects of lower significance, conservation decisions are more likely to result from the judgment of a single individual than from the evaluation of a conservation board; and if "common sense" is not enough to guide a deciding board, then certainly it is quite insufficient to guide single individuals.

## *4.2. The compatibility of built heritage cleaning*

As may be judged from Table 2.9 (Section 2.2.6), the concept of 'compatibility' has most extensively been applied to materials, where physical-chemical affinity, similarity (analogy, homogeneity,…) and/or non-harmfulness between the material constituting the heritage object and the material used to conserve it are generally considered sufficient requirements for the adequacy or suitability of the latter. This material approach, however, falls short when analysing cleaning compatibility. Firstly, cleaning is mainly about the removing, and not the adding, of material; in principle, no remnants of the cleaning products should remain on the cleaned surface. Thus, unlike consolidants or repair mortars, where harmfulness may be (at least tentatively) appraised from, for instance, changes in resistance features or water behaviour, these parameters would be insufficient or simply not applicable when assessing cleaning options. On the other hand, the compatibility of cleaning interventions obviously cannot be grounded on material similarity, and the possible deleterious effects of product residues, either in the short- or in the long-run, represent only one part of the problem at hand when planning cleaning interventions. Additionally, cleaning is, by definition, irreversible; even if irreversibility is no longer considered the key conservation principle that it once was (Dei 2013; Sasse & Snethlage 1997; Teutonico et al. 1997), this characteristic heightens the damaging potential of cleaning operations and, therefore, the importance of precautions that must be taken at planning, execution and control stages.

Following the definition proposed in Chapter 2 (Section 2.2.6), analysing heritage cleaning compatibility corresponds to determining the extent to which a cleaning intervention, action and/or method may be used upon a heritage object without putting its present or future significance at risk. In other words, a cleaning compatibility analysis should ascertain how cleaning actions will impact on the significance of the heritage object and offer advice on how to decide on the *tolerable extent of that impact*.

To assess the compatibility of cleaning actions towards the significance of a heritage object we firstly need to understand how this significance can be hindered by said actions. Significance is a multifaceted concept that encapsulates the many different dimensions, or values, that cause an object to be considered heritage by a given social group, in a given moment of time. In the case of tangible heritage, and particularly in Western European societies[35], this concept generally relies very heavily upon the fabric of the object, i.e. all the physical materials associated to the object, which may even include deposits – for instance, soiling, to a certain extent, was shown to have a positive effect on the public perception of the aesthetic value of a building (Andrew 2002); endolithic fungal growths may behave as stone protectives from atmospheric contaminants (Concha-Lozano et al. 2012); and defacing violence-inciting vandalism may be viewed as a significant present-day testimonial and thus be incorporated into an artwork (Borghese 2015) – as Brooks & Eastop have put it vis-à-vis textile cleaning, "dirtiness and cleanliness are culturally and socially determined" (2006: 172).

[35] The notion of 'historic monument' as an object selected among existing objects because of its values for history and/or art (as opposed to an object created intentionally to serve as a memory token) is at the core of the definition of 'heritage object' and is a specific Western European cultural creation (Choay 2011).

Significance is, therefore, hindered by any action that causes its embodying materials to be damaged or lost – and this is the primary focus of the compatibility analysis below. Integrity, be it physical or conceptual, will also heavily rely on the fabric; as will authenticity, given that, oftentimes, the fabric is the most important source of information about the object. The compatibility analysis below primarily focuses on significance, but it is applicable, by extension, to the authenticity and integrity of the object as well, as per the definitions given in Chapter 2.

The aim of this research was to provide a straightforward tool to aid in the planning of cleaning interventions, and namely in the choosing of a cleaning method based on its compatibility towards the significance of the object. The two main requirements for this tool are:

- Comprehensiveness: it should encompass all the parameters that are relevant in a heritage-compatible cleaning intervention;
- Comparability: it should allow (1) for comparisons between different cleaning methods and (2) for the setting of acceptability/tolerance thresholds that enable its integration in a decision-making process.

Considering the compatibility definition proposed above, any compatibility assessment should be about analysing the extent to which significance may be 'put at risk' by a given 'product, method or action'; it is, argued that a risk assessment-based method may aid in the development of such a tool. It must be underlined that heritage cleaning, like any project involving such a multitude of factors, will never be risk free; planning should thus be about managing that risk. The following chapter is thus devoted to the identification and analysis of the incompatibility risks that may be brought about by cleaning actions.

## 4.3. Some remarks

Heritage cleaning is a delicate process that aims at preserving or enhancing the significance of the object, whilst respecting its authenticity and integrity. It is therefore necessary to analyse how these concepts are translated in the materiality of the object before the cleaning goals are established. Materially, the cleaning goals correspond to a cleaning level or target surface, to be chosen and duly justified.
The choice of a target surface is never fully dissociated from the choice of cleaning methods, and two key factors determining this choice are the effectiveness and non-harmfulness of those methods. The current proposal suggests that *non-harmfulness* may profitably be replaced by *compatibility*, a conservation principle that seems to more aptly convey the idea of *non-harmfulness in the long run*.

Albeit many authors propose assessment methods that evaluate both effectiveness and non-harmfulness (or compatibility) without clearly distinguishing them[36], it is argued that these evaluations may in fact be separated, as proposed by Mecchi (2008) for cleaning and by Delgado Rodrigues & Grossi (2007) for the compatibility assessment of conservation actions. As the latter authors put it, the "compatibility/incompatibility assessment comes as a step downstream to effectiveness and it shall be introduced in the process only when the effectiveness of the given action can be guaranteed within acceptable limits" (2007: 33). The analysis undertaken here presupposes the effectiveness of the methods, and deals essentially with the assessment of their compatibility, thought of as non-harmfulness in the short- and long-run, towards the significance of the object.

Several recommendations and proposals of procedures for the assessment and/or choice of a cleaning method have been put forward in the past decades. Nevertheless, they generally lack

[36] As remarked by Mecchi: "Many authors recognize the problem of cleaning evaluation by effectiveness and harmfulness criteria, but no one is able to clearly distinguish the two requirements carrying out distinct and specific laboratory measurements." (2008: 426)

objective acceptability criteria, either due to onsite testing/sampling limitations (Laurenzi Tabasso & Simon 2006), availability and/or sensitivity of the testing methods (Mecchi et al. 2008), lack of a common approach (Mecchi et al. 2008; Vergès-Belmin 1996) or the diversity of substrate/deposit/environment combinations (Mecchi et al. 2008); nor do they offer the conceptual tools to generate such criteria. On the other hand, most of these procedures may pose practical implementing difficulties because of budgetary constraints, which may preclude scientific consultation or testing in the planning of conservation actions particularly for objects of relatively lower significance and/or located in regions with fewer resources. Therefore, simple and integrating methodologies may bring relevant contributions at this stage.

The current proposal uses the concept of compatibility and attempts to operationalize its associated recommendations into systematic guiding criteria for the selection of cleaning methods.

It is postulated that a compatibility evaluation of cleaning actions may be operationalized resorting to an (in)compatibility risk assessment, where parameters derive from a risk analysis of heritage cleaning. This analysis permitted building up a procedure based on semi-quantitative evaluations of determinant factors, which will ultimately result in a risk-evaluation tool, thus assisting potential users in the planning of cleaning interventions. After all, “The bottom line [in choosing conservation treatment methods] is risk assessment. […] the job of a professional is not risk *avoidance* but risk *management*. Strategies to lessen the probability of damage cannot be successful unless the risk is acknowledged and identified.” (Appelbaum 2010: 366, italics in the original source)

# 5. (In)compatibility risk analysis of built heritage cleaning

*When there is a risk, there must be something that is unknown or has an unknown outcome. Therefore, knowledge about risk is knowledge about lack of knowledge.*

S.O. Hansson (2014)

The forthcoming sections are dedicated to the application of risk assessment techniques to the cleaning of built heritage, trying to systematize current knowledge (or lack thereof) in the field of built heritage cleaning. The presented risk analysis is based on the steps described by Caldeira[37] (2005), starting with the definition of the *Scope & goals,* followed by the *System characterization*; in the ensuing *Risks identification*, a tentatively exhaustive description of the risks involved in built heritage cleaning is presented. The risks are then analysed using the *Risk Index Method*, which allowed for the development of a risk assessment proposal. This proposal, as presented in Revez & Delgado Rodrigues (2016), constitutes the intended decision support tool for the planning of heritage cleaning.

## *5.1. Scope, goals & system characterization*

*To assess risk you have to have a clear idea of what you intend or hope for, otherwise it will not be obvious that anything has gone wrong.*

J. Ashley-Smith (2001)

### 5.1.1. Scope & Goals

The scope of the analysis is the planning of built heritage cleaning interventions, whether they are included in a wider conservation programme or not. More specifically, the current assessment deals with the *incompatibility risks* of cleaning actions, i.e., the risks of cleaning actions having harmful consequences upon heritage significance (or authenticity or integrity), directly or indirectly, immediately and/or belatedly. The analysis presupposes the effectiveness of those cleaning actions, assuming that there is no need to analyse operational choices that do not solve the cleaning problem. It should also be highlighted that this analysis does not contemplate polychromed surfaces.

The goal of this risk analysis is to develop a tool for supporting the planning of heritage cleaning interventions via a systematic survey of the risks that these interventions pose to the

[37] Which broadly corresponds to the sequence proposed by the Australian and New Zealand standard AS/NZS 4360 (2004a).

concerned objects, with the ultimate objective of pointing the decision maker/planner towards the most compatible cleaning options.
Heritage cleaning interventions aim at preserving or enhancing the significance of an object, while respecting its authenticity and integrity. Therefore, in the context of cleaning, and following the definitions in previous chapters, an action or method will be incompatible if it threats object significance at an unacceptable level.

### 5.1.2. System characterization

A heritage cleaning intervention is a complex system revolving around three main axes: the object, the cleaning method(s) and the involved actors; the interactions among these will determine the outcome of the intervention and the risks of damage occurring. When performing a risk analysis, establishing the context will entail a rigorous characterization and recording of the whole system at hand.

#### *The object*

The object is the focal point of this system. In terms of materials, built heritage objects are typically diverse, integrating stone, ceramics and/or mortars in myriad possible combinations. Building stones may be igneous, metamorphic or sedimentary and, within each type, will vary widely in behaviour and appearance depending on their chemical and mineralogical composition and specific conditions of exposure to weathering agents. Ceramic materials, including bricks and tiles, as well as mortars, commonly used for joints and/or as renders, are men-made composite materials that will be strongly contingent of the locally available materials and technology, as well as of their particular response to weathering phenomena, and therefore may also display a vast array of behaviours and conditions. It is the particular chemical and physical features of each material at the moment of the intervention that will ultimately dictate its ability to withstand the cleaning actions.
On the other hand, the agglomerate of materials that constitutes each object is also the repository of the majority, if not all, of the values that cause it to be perceived as heritage and thus conserved. Therefore, the impact of the cleaning must be predicted and assessed considering both material and immaterial features.

#### *The cleaning methods*

There are many cleaning methods available and commonly employed in built heritage conservation, as indicated in Table 4.1, where different methods were listed according to the type of deposits they are reportedly able to remove. For a systematic risk assessment, it is useful to categorize these methods by cleaning principle or technique, as presented in Table 5.1.

**Table 5.1:** Groups of built heritage cleaning methods

| Cleaning group | Cleaning principle/technique | Cleaning methods (for stone heritage) |
|---|---|---|
| Mechanical | Soiling is removed by abrasion with hand tools or by the impact of particles or micro-particles under controlled pressure; or by the action of mechanical waves. | Hand tools: scalpels, spatulas, brushes, rubbers |
| | | Microparticle jet: particle size 0.05-0.10 mm (including dry ice) |
| | | Particle jet: particle size 0.1-0.5mm |
| | | Pneumatic tools |
| | | Ultra-sounds |
| Water-based | Water-based methods, using cold or hot water, may act:<br>• Chemically, by promoting the dissolution or swelling of the soiling layers, to facilitate subsequent | Nebulized water (mist) (w/ or w/o brushing) |
| | | Water sprinkling (w/ or w/o brushing) |
| | | Wet particle jet, i.e. wet grit blasting |
| | | Pressurized water spray (w/ or w/o brushing) |

| | | |
|---|---|---|
| | (mechanical) removal with resort to brushing; and/or<br>• Mechanically, when manual or automatic pressure is employed. | Water steam (w/ or w/o brushing)<br>Desalination poultices |
| Chemical | Cleaning occurs by dissolving the soiling substances in adequate solvents, or by promoting their solubility in water with chelating agents, surfactants or ion-exchange resins; chemical cleaning products are often applied as poultices, but may also be used in the form of gels or solutions. | Chelates, e.g. EDTA sodium salts |
| | | Weakly acidic or alkaline solutions |
| | | $(NH_4)_2CO_3$ |
| | | Ion-exchange resins |
| | | Biocides |
| | | Neutral or non-ionic surfactants |
| | | Organic solvents (aromatic or aliphatic) |
| | | Enzymatic and bacterial cleaners |
| Ablation | Soiling is removed by the action of electromagnetic radiation. | Laser |

N.B.1: Due to their high risks, and given the alternatives described above, the following methods should be altogether avoided (see, for instance, Rossi Manaresi (1977), Lazzarini & Laurenzi Tabasso (1986) and Snethlage (2011)) and, as such, are not listed above:
- strongly acidic and alkaline reagents;
- high pressure (>2MPa) water jets;
- high pressure (>0.5MPa) steam jets;
- high pressure (>2MPa) (industrial) wet or dry particle jets;
- cationic and anionic surfactants.

N.B.2: Desalination resorting to electromigration is not included here because it is still not sufficiently developed for built surfaces to be analysed in terms of compatibility.

### *The actors*

Due to the usually large scale of the interventions performed upon built heritage, there may be many professionals involved throughout the different stages of the process, including planning, execution and control.

The heritage authorities responsible for the site will evidently play a crucial role from the start, both in assigning the different professional roles and in defining the guiding conservation concept. It is generally recommended that conservation-scientists should be responsible for the planning stages, and, even for the definition of the conservation concept, the consultation with heritage experts is advised (Delgado Rodrigues 2007). On the other hand, consulting and/or communicating with the stakeholders, i.e. the social group(s) invested in the preservation of the object, may be extremely relevant, as highlighted in Chapter 2.

The execution of heritage cleaning interventions should be assigned to teams led by conservator-restorers (Delgado Rodrigues 2007), adequately trained and experienced in working with the materials in question.

Besides the contractors, the site authorities are also responsible for choosing adequately prepared control agents for supervising the intervention.

### *The system*

Schematically, the system may be described by the figure below.

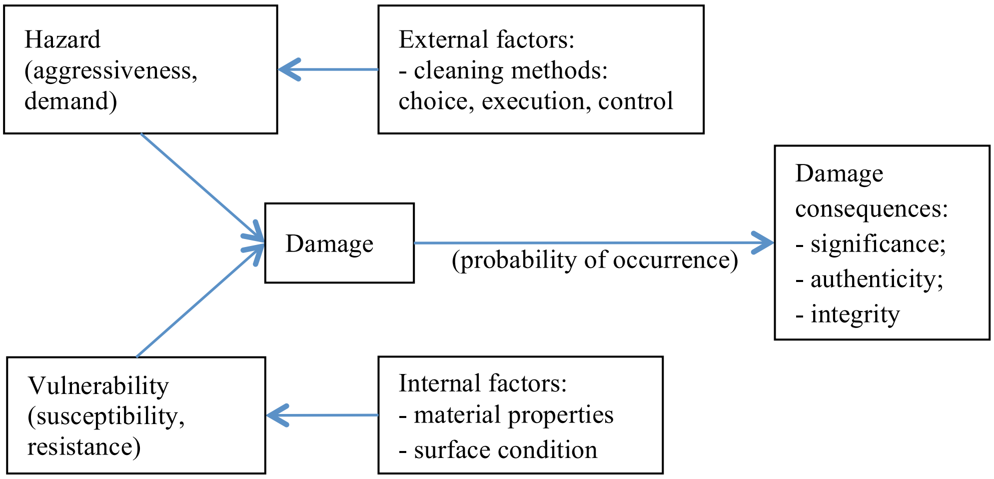


**Figure 5.1**: Determinant factors in the risk analysis of built heritage cleaning actions; adapted from Caldeira (2005: 9).

Damage is "a concept, not a physical fact" (Appelbaum 2010: 363); for all intents and purposes of this research, damage is defined as an "alteration that reduces significance" (adapted from EN 15898:2011: 9); thus, the current analysis is dedicated to significance-reducing alterations caused by cleaning interventions.
As per the scheme in Figure 5.1, damage will be the result of the occurrence of a hazard to which the object is vulnerable; hazard and vulnerability depend on, respectively, external and internal factors. In the current context, external factors are related to the cleaning methods used, which may be more or less aggressive depending on how and why they are chosen, executed and controlled.

Internal factors governing the vulnerability of the object rely on its materiality: in stones, this vulnerability is typically a function of: "petrography, mineralogy, chemistry, structure, texture, as well as physical characteristics such as porosity, permeability, colour, hardness" (Del Monte 1991: 79), including features induced by weathering, be they inherited from the quarry or developed after application in the object; in mortars and ceramics, the physical and chemical characteristics of the different components, as well as the interactions between them and presence of heterogeneities will be the determining factors, along with conservation condition. Given the nature of cleaning actions, *surface* condition will be particularly relevant in all materials, including geometry, finishing and weathering-induced features, which may vary across the same object.
If damage occurs, there will be consequences upon the significance of the object, which will be directly proportional to the level of significance ascribed to it by its relevant stakeholders. It may be useful to remember that "the aim of those investigating damage is also to assist in establishing the historical identity of [heritage objects], especially those which are partially or wholly lacking in historical sources" (Del Monte 1991: 78).

## *5.2. Risk identification*

### 5.2.1. Identification of sources of damage during stone cleaning

Any damage caused during a built heritage cleaning intervention will have been caused by one of the following, separately or in combination:

1. Deficiencies at the conception or design stages:

- ill-defined intervention goals (including ill-defined and/or ill-justified target surface; absent or poor deposit impact analysis; etc);

- poor conception of the intervention at technical level (for instance: not considering the need for preliminary tests; not having a well-characterized reference surface for assessing results; not having agreed upon a reference surface with the contractor; not controlling hydraulic properties; etc.);
- misjudgement of the substrate properties (e.g. resistance and chemical composition);
- misjudgement of the substrate condition (e.g. moisture content, decay patterns, presence of polychromy);
- misjudgement or inversion of priorities and decision weights in the assessment criteria (cost, risk, duration, past experience of contractors, etc.)

2. Anomalies on the operational procedures:

- operation(s) incorrectly performed (excess of water, higher working pressure, stronger tools, higher concentrations, etc.) due to equipment failure;
- operation(s) incorrectly performed due to human error or lack of sufficient skills/experience.

3. Deficiencies at control level

- Unqualified supervisors;
- Insufficient supervision actions.

### 5.2.2. Identification of potential damage mechanisms in cleaning actions

In the context of a cleaning action performed upon built heritage, and considering the definitions of compatibility given earlier, three types of damage phenomena were identified:

(i) Mass loss: direct mass loss will basically occur when the target surface of the object is unable to withstand the external solicitations entailed by the cleaning intervention; it is a superficial damage caused by cleaning beyond the compatible target surface.
(ii) Discolouration: corresponds to an undesirable change in the colour features of the object.
(iii) Indirect damage: sub-superficial damage including all undesirable changes inflicted upon the object via non-immediate mechanisms, including threats to the future stability of the object.

The scenarios under which these types of damage may occur are explored below, after a brief not on why under-cleaning is not considered damage here.

**Note on under-cleaning**

Under-cleaning means *inadvertently* leaving behind deposits that had previously been found deleterious, i.e., this definition does not include the case where deposits initially intended for removal are *deliberately* left behind for lack of an effective and compatible cleaning method to eliminate them. It is acknowledged that some deposits are extremely difficult to remove: De Clercq & Godts, for instance, question the use of the term ‘salt extraction’ when using desalination poultices, since “a major part of the salts is pushed inwards”, a “phenomenon [that] seems to be inevitable” (2014: 466); and Chapman (2000) reported unsightly ‘ghosting’ evidence thirty years after the cleaning of a graffiti attack on Stonehenge. However, these are ultimately effectiveness issues, and thus, as highlighted earlier, not considered here.

The incompatibility of under-cleaning is akin to the incompatibility of not cleaning, and will vary according to the harmfulness that the unwanted deposits are inducing on the significance of the object. The endless possible combinations in the triad deposits – substrates – environmental conditions prevents its general risk assessment, which is also the reason why the current assessment does not contemplate or allow for the comparison with the option of not cleaning the object.

### 5.2.3. Identification of damage scenarios

Identifying damage scenarios means to exhaustively ascertain the relationships between damage causes and consequences. Therefore, this section explores the above-listed mechanisms that may lead to damage occurring during a heritage cleaning intervention. It is nevertheless noted that, as remarked by Del Monte,

> The relationship between the type of material, environmental factors and damage entity is in many cases unknown. Therefore, it is not yet possible to provide a quantitative expression of damage or percentualize the contribution of the various factors, We can only proceed by hypothesis, comparison and analogy. An analogy is not a unit of measurement and is therefore not quantitatively identical to that which is represented through it; only the quality of damage can be indicated (1991: 87).

Going one step further, Viles asked if stone decay systems could be chaotic and proposed ten sources of non-linearity influencing the environmental response of stonework as a step towards a better understanding of its complex behaviour and, consequently, better management strategies (Viles 2005). Many of these sources are applicable to built heritage cleaning: for example, water-based cleaning methods may contribute to the occurrence of salt crystallization and/or frost damage, which will only cause damage when the stone strength 'threshold' is exceeded; if the two processes occur concomitantly, a 'synergism' will take place; lichen colonization may be "[conceptualized as] a competition between bioweathering by the lichen (through biochemical and biophysical breakdown under the thallus) and bioprotection (through the net protection afforded by the lichen covering the stone surface)" (Viles 2005: 15) and these 'competitive interactions' will likely be disrupted by the action of biocides; the carving of decorative elements may create "weathering «hotspots»" (Viles 2005: 14) which will be particularly prone to damage.

Consequently, linearity is not only difficult to establish, it is also often absent from damage mechanisms, and thus the scenarios described below are exactly that – descriptions, or tentative descriptions, of the damage factors at play during the cleaning of a heritage object with different methods.

#### I. <u>Immediate/direct mass loss</u>

Mass loss is defined here as an *undesirable* loss of material; this section refers specifically to material loss caused by (over) cleaning. This material may originate from the substrate, but it may also correspond to deposits sitting on top of the substrate or to altered layers corresponding to substrate material that has interacted with weathering agents, e.g. patina.

The undesirability of mass loss is rooted on its detrimental effects on the significance, authenticity and/or integrity of the object. This loss may be immediate and/or manifest in the long term, since cleaning may enhance the vulnerability of the substrate to resoiling and/or further weathering by increasing surface roughness and/or erosion, and thus the specific surface area (Maravelaki et al. 1992); some authors believe that where harsh cleaning methods are used the decay rate may be greatly accelerated (Young et al. 2000).

Attention is drawn to the fact that mass loss may occur at a near microscopic scale, which will often be uneven, depending on the mineralogical features of the substrate and on the operator skills. Nevertheless, judgements should be cautious, since the removal of soiling deposits will most likely increase surface roughness to some extent (Snethlage & Sterflinger 2011). And, as Doehne and Price have put it, "a degree of scepticism would perhaps be justified over «damage» that is observable only through a scanning electron microscope" (2010: 30).

Mass loss, either at a macroscopic or microscopic level, will of course depend on the vulnerability of the material to the aggressiveness of the method. Heavily decayed substrates, with active detachment phenomena, such as sanding or scaling, will obviously show a poor resistance to the vast majority of the available cleaning methods, and Werner goes as far as to affirm that "the different state of weathering influences the result of the cleaning much more than the applied cleaning method" (1989: 688). On the other hand, the objects may contain components that are chemically vulnerable to certain cleaning agents. The main identified mass loss mechanisms are physical (mechanical or thermal) or chemical in nature and include (i) abrasion, (ii) dissolution and (iii) fissuring, as detailed below.

*(i) Abrasion/ablation*

Undesirable material loss may occur by abrasion whenever the mechanical resistance of the target surface is insufficient to withstand the impact of solids and/or fluids used in the cleaning procedure or the hardness of the cleaning instrument. Abrasion may occur, for instance:

- when over-aggressive hand-tools are used, e.g. a steel brush on a soft stone;
- with an over-aggressive use of pneumatic tools;
- when ultrasound cleaning tools are used on deposits that are harder than the stone (Domasłowski & Kwiatkowski 2003);
- with mechanical or water pressure-cleaning methods, when using excessive pressure or inadequate particles, nozzles or working distances/angles;
- finally, laser may also cause mass loss (by ablation) if its working parameters are not adequately adjusted.

Given their higher complexity and relatively frequent usage, a few notes on the particulars of pressure and laser cleaning are outlined below.

<u>Wet and dry particle or micro-particle jets</u>

Mechanical pressure methods blast particles (0.1–0.5mm) or micro-particles (0.05-0.10mm) (Snethlage & Sterflinger 2011), with or without water, at a controlled pressure; cleaning results mostly from the mechanical impact of the particles on the deposits. The controllability of the method of course plays a large role in its damaging potential, and therefore parameters influencing particle impact values are decisive. Particle kinetic energy (E) is given by:

$$E = \frac{1}{2}mv^2$$

Where m= mass; and v = velocity

Therefore, relevant parameters influencing the aggressiveness of particle jets include, in terms of equipment, not only pressure and time, but also distance, angle of incidence, nozzle diameter and flow; and, in terms of particles, size, morphology, shape, density, hardness and friability (Iglesias-Campos 2014; Iglesias-Campos et al. 2014).

As a rule of thumb, round particles will cause less damage than edged particles, as will lower-density particles when compared to higher-density particles; organic particles, e.g. kernel and/or shell granulates, polycarbonates, are generally less dense than mineral particles, e.g. alumina or glass beads. On the other hand, particles of a smaller diameter will exhibit a lower kinetic energy, making them more controllable (Lazzarini & Laurenzi Tabasso 1986), although, in certain cases, smaller particles may be able to penetrate the space between aggregate grains more easily and thus enhance the erosion of the binder or cement of the substrate (Iglesias-Campos et al. 2015). Particle hardness should also be considered, since Mohs scale values may vary widely (e.g. between 2.5 for kernel and/or shell granulates and 9 for alumina (BSI 2000)).
Fassina mentions micro-particles between 27µm to 60µm (between around 500 to 250 mesh) to be acceptable for “cleaning even very damaged stones and poorly resistant surfaces, after a previous consolidation” (1993: 130), providing that the powder flux is kept at 20%-30% of the maximum values, with the minimum possible air stream values; higher flux and airstream values are possible for sounder stones.

Lazzarini & Laurenzi Tabasso (1986) restrict particle jet, wet or dry, to low-significance surfaces, using maximum pressures between 0.05MPa and 0.30MPa; for significant objects, only micro-particles (40 µm) should be used; the same pressure values are recommended by Fassina (1993) for wet grit blasting. J. Ashurst (1990) suggests slightly lower values for wet grit jets (0.12MPa-0.2MPa) than for dry jets (0.14 MPa-0.28 MPa). Andrew et al. warn against the use of either of these methods on “polished surfaces or on areas of delicate architectural detail or carvings” (1994: 56), unless very low pressures – typically between 0.02MPa and 0.04MPa

are used. Gaspar et al. (2003) reported surface damage in oolithic limestone samples after micro-particle jet cleaning at 0.1MPa and reject this method altogether for this lithotype; these authors furthermore affirm that cleaning terracotta with a micro-particle jet at 0.4MPa induced surface changes "clearly associated with the complete destruction of the fireskin layer" (2003: 297s).
Snethlage (2011) mentions values between 1 and 2 MPa for particle jet, but points out that the impact pressure will vary (negatively) with the distance from the nozzle to the stone surface and recommends that the nozzle makes a 65º angle with the surface at a 20-30cm distance. Similarly, Iglesias-Campos et al. report that surface damage caused by particle jet is partly due to friction mechanisms favoured by lower impact angles (25º and 45º), and as such confirm that using an angle around 75º will cause less damage, at least in sandstones (Iglesias-Campos et al. 2014) and lime renders (Iglesias-Campos 2014), although the aggressiveness of the impact will again increase for 90º angles. The study furthermore proved that wider nozzle diameters, ceteris paribus, will reduce the aggressiveness of particle jets (Iglesias-Campos et al. 2014).

Evidently, the potential damage of wet or dry grit blasting will also vary depending on the substrate and surface features of the object to be cleaned; less compact, i.e., more porous, materials will be more easily abraded. Grimmer (1979) highlights the dangers of blasting cleaning methods eroding the outer harder layer of ceramic materials, e.g. bricks, and exposing the softer inner layers, making the objects more prone to weathering; as for plaster and stuccoes, softer than ceramics, these materials will "completely disintegrate" (Grimmer 1979: 4) if treated with particle jets; stone materials will generally be more compact and thus resistant, but surface textures, e.g. polished finishes, and/or other detail features such as sharp edges, crisp decorations or tooling marks, may become "worn or pitted" (Grimmer 1979: 5) following abrasive cleaning.

For Andrew et al., both dry and wet grit blasting are, in practice, "difficult to control" and lend themselves to be "easily misused" (1994: 49) by operatives eager to expedite the cleaning action, making adequate training and supervision critical (Grimmer 1979). Already in the 1971 Bologna Conference, Mamillan & Simonnet had pointed out that the "dexterity and professional conscience of the employed workers are of crucial importance" (1972: 205) when using wet grit blasting in heritage objects. In 1995, Alessandrini et al. mentioned the "extreme criticality" (1995: 596) of micro-particle blasting due to the difficulties in controlling both the distance between the surface and the nozzle and the operating time, even for a skilled and attentive operator.

Water-pressure methods

Regarding water jets, Fassina restricts the use of pressurized water, at maximum pressure values between 0.2MPa and 0.3MPa, to "unimportant walls" (1993: 128); Lazzarini & Laurenzi Tabasso, however, suggest that "buildings of historic or artistic interest" (1986: 112) may be cleaned using pressures of circa 0.25MPa to 0.4MPa; Aires-Barros (2001) accepts pressure values between 0.5MPa and 1MPa, which are nevertheless not recommended for decayed soft stones. Andrew et al. refer to 1.3MPa pressures as 'low', but alert nonetheless for the fact that even low pressure values may damage soft stones or already damaged areas; the authors furthermore highlight the importance of the nozzle spread, which should not fall below 15 degrees; and of considering the water flow, regarding which 4.5l/min are recommended for "delicate work" (1994: 46). Slaton & Normandin (2005) suggest that pressures between 2.75MPa and 5.5MPa may be used in very resistant stones, such as granites.
As a corollary, the cutting power of a water jet depends on the used pressure, water flow, and area of the surface hit by the water (which will, in turn, depend on the nozzle diameter, shape and working distance); this is expressed by the formula (Ashurst, N. 1994a; Heritage Victoria 2001):

$$water\ jet\ cutting\ power\ = \frac{PQ}{a}$$

Where:
P = pressure at the pump (in kPa)

Q = flow rate of water (in l/min)
a = area of the surface covered by the jet (in cm)
Heritage Victoria terms this ratio 'abrasion factor' and recommends for it to be kept below 2000 "for normal sound sandstones" (2001: 3).

Water at higher temperatures, according to N.Ashurst, may be more efficient in the removing of organic deposits, or in assisting the action of some chemical cleaners, but the author advises for it to be kept below 95ºC and at pressures below 1.3MPa and cautions that thermal shock may occur "to some masonry" (1994a: 9).
Pressurized water vapour uses less pressure (around 0.05MPa), and comparatively less water than cold water methods, but it does heat the stone, which may cause relevant damage (Fassina 1993), and it is unadvised for soft sandstones (Aires-Barros 2001). Snethlage mentions the cleaning efficiency of using 2MPa to 4MPa pressures with water heated between 140ºC and 180ºC, nevertheless alerting for the risks of material loss in "sanding and flaking surfaces" (Snethlage & Sterflinger 2011: 447).
As a rule of thumb, hard water is recommended for carbonated stones, whereas demineralized water should be preferred for granites (Fassina 1993).

Laser

Laser will be a self-limiting cleaning method if the ablation threshold for the particles to remove is "significantly lower" (Rodriguez-Navarro et al. 2003: 69) than the equivalent threshold for the matter to preserve. If, however, used outside of the safety thresholds, laser cleaning may have undesirable side effects, such as inducing the melting of minerals, changes in surface texture or discolouration (see below) (Siano et al. 2000). Values for pulse energy, pulse duration and pulse frequency rate should be carefully determined, and may need a combination of analytical techniques to be ascertained precisely (Rodriguez-Navarro et al. 2003); also influencing the safety thresholds are the texture and composition of the substrates, as well as irradiation conditions (wet or dry) (Esbert et al. 2003; Rodriguez-Navarro et al. 2003).
On the other hand, Rodrigues-Navarro et al. mention that even within the safety threshold, photoacoustic effects may cause damage to occur, highlighting the need for "continuous monitoring" (Rodriguez-Navarro et al. 2003: 69) during the cleaning process, especially when considering that differences in the mineralogical composition of the substrate will imply shifts in the safety thresholds as cleaning progresses.

A topographical comparison of different substrates after cleaning with different methods revealed that, in marbles, the increase in surface roughness was highest when using laser above the ablation threshold, a variation that is "easily correlated to the ablation of calcite crystals" (Gaspar et al. 2003: 296s). Experiments in samples of Pietra d'Istria, a limestone containing clay-mineral inclusions, denounced the partial melting of some of these argillaceous components with excessive irradiation values (Biscontin, Zendri, Bakolas, Polloni, et al. 1995).
In polymineralic stones such as granites, the application of laser is still incipient due to the presence of minerals that are sensitive to the radiation used, including ferromagnesian micas (e.g. biotite) and some feldspars (Delgado Rodrigues et al. 2014). For instance, Pozo et al. (2014) reported the partial melting of potassium feldspar, biotite and plagioclase, causing changes in surface roughness and colour, when using radiation at 1064nm, with severe mineralogical damage being reached at high fluencies; Esbert et al. (2003) refer to biotite as the mineral the most affected by laser in experiments conducted in Rosa Porriño granite specimens, to the point that it may reach its melting point.
Tests conducted in Sienna sandstone also accused the shift of the iron oxides from limonite to haematite and the partial melting of "ocraceous altered framework grains" (resulting from altered mafic minerals), which displayed a very high absorption at the wavelength of the Nd:YAG laser used (Siano et al. 2000). Siano et al. (2000) furthermore state that the wetting of the surface prior to laser cleaning will help in reducing mechanical and thermal damage, a result which was also verified by Esbert et al. (2003) for colour damage. Gaspar et al. (2003) also noticed lower levels of surface roughness in marbles cleaned with laser after pre-wetting, but

the opposite effect occurred in the oolithic limestone samples, apparently because the water was vaporized at a sub-superficial level.

Safety thresholds will vary for each substrate, and the analytical techniques that may assist in their determination, as well as in cleaning monitoring, are diverse; a list of these techniques and their applicability may be found in Rodriguez-Navarro et al. (2003: Table 2). Mecchi et al. (2008) additionally mention the UNI 11187:2006 standard as an onsite user-friendly reference for guidelines and a methodology to evaluate and choose laser cleaning equipment parameters.

*(ii) dissolution caused by water, acidic or alkaline cleaners or chelating agents*

Chemical cleaning methods may change the solubility of some of the target surface components, which may lead them to dissolve into the cleaning solutions or become more water soluble and eventually be washed off. Acidic or alkaline cleaning solutions, as well as solutions containing chelating agents, are typical examples: the reaction of calcite to (even weak) acids is well known; in high enough concentrations, strong acids may dissolve feldspars or clay minerals (Snethlage & Sterflinger 2011); both carbonate and silicate stones are prone to attacking by strong alkaline solutions (Lazzarini & Laurenzi Tabasso 1986). Chelating agents, in turn, function by capturing metal ions, including calcium, and may be applied in non-neutral pH solutions, which will add to the risks of dissolving the substrate; their aggressiveness may vary greatly, and must be judged considering not only the type of agent, but also its concentration and the pH of the cleaning solution (Fredd & Folger 1998; Gervais et al. 2010). For instance, it has been demonstrated that di-sodium EDTA is more harmful than tetra-sodium EDTA when used in stones with calcitic binders and/or components, since its lower percentage of sodium ions yields solutions with a much lower pH than its tetra-sodium counterpart; and is thus more effective in solubilizing calcite (Thorn 1993).

Furthermore, the chemical composition of the cleaning agent is not necessarily the sole determining factor: for carbonate stones, porosity has been proven to play a key role in weathering via dissolution mechanisms, especially in superficial areas (Van Den Eynde et al. 2013).

The use of strong acids and alkalis, although popular in the past, is firmly advised against today, since (1) controllability and neutralization are difficult, fallible and harmful (Lazzarini & Laurenzi Tabasso 1986; Snethlage & Sterflinger 2011); (2) there are robust alternatives, such as water-based methods, laser or microparticle jets (Snethlage & Sterflinger 2011); and, (3) even if the stone is not perceivably damaged, resoiling is faster (Robert Gordon Institute of Technology studies, quoted by Snethlage (2011)). Although classified as weak, hydrofluoric acid may also have a very damaging effect on carbonate stones, by forming calcium fluoride, which is considerably smaller than the carbonate and thus may cause fracturing; in siliceous stones, both hydrofluoric acid and ammonium bifluoride are able to form gaseous silicon tetrafluoride (Villegas Sánchez et al. 2003); its use is also cautioned against in polished granites and glazed tiles (Ashurst, N. 1994a).

Other weakly acidic and basic solutions, as well as chelating agents, may sometimes be used for localized stains in carbonate substrates (Snethlage & Sterflinger 2011); siliceous stones with similar staining will allow for the use of slightly stronger acids, e.g. phosphoric acid, combined with a chelating agent such as a citrate, according to Lazzarini & Laurenzi Tabasso (1986).

*(iii) fissuring due to the use of heat*

Steam jet cleaning may induce the formation of fissures when used on stones with anisotropic minerals or containing minerals with different thermal behaviours: “as a consequence of their high thermal anisotropy, large calcite crystals are prone to fissuration when heated, and polymineralic rocks such as granites may undergo fissuration as a consequence of the large difference of thermal behaviour between quartz and feldspars minerals” (Delgado Rodrigues & Castro 1989: 494).

Gaspar et al. (2003) reported fissuring in terracotta and oolitic limestone samples after cleaning with a 15 centimetre-distant steam jet at 130ºC, with pressures between 0.1MPa and 0.4MPa, for contact periods above 15 and 10 minutes, respectively. The study shows that specimens with a higher porosity, and therefore featuring lower resistances and higher specific surfaces, are more vulnerable to the impact of steam cleaning.

## II. Surface discolouration

Discolouration is defined here as an *undesirable* "Change of the [surface] colour in one to three of the colour parameters: hue, value and chroma." (ICOMOS-ISCS 2008: 46); this section refers specifically to discolouration caused by cleaning.
Discolouration caused by cleaning may ensue from unintended/undesirable alterations of the target surface caused by the cleaning method; or from cleaning agent residues left behind.

*(i) changes in the oxidation state of iron and/or manganese present in the substrate by action of a chemical cleaning agent*

The presence of minerals containing iron and/or manganese, even in trace amounts, will cause the substrate to be particularly susceptible to colour changes when in the presence of cleaning agents that are able to change the oxidation state of those metals. This discolouration will of course depend on the amount of metal ions present, but also on the type, concentration and dwell time of the used cleaning agent, including phenols-containing biocides (Andrew et al. 1994), chelating agents and, presumably, any of the compounds suggested in Table 4.1. for the cleaning of metal stains. Iron-containing sandstones, limestones and granites may also undergo ferric oxide staining if treated with alkaline cleaners (Ashurst, N. 1994a).

*(ii) Discolouration following laser cleaning*

Coloured substrates, containing iron oxide, hydroxide and/or sulphide minerals, may undergo discolouration due to water release caused by laser heating, e.g. the so called 'red-shift' (Siano et al. 2000), and/or iron photo-oxidation (Esbert et al. 2003), which may induce changes at the crystallographic structure level (Snethlage & Sterflinger 2011). Rose-coloured feldspars may also be affected by laser cleaning (Doehne & Price 2010; Esbert et al. 2003).
In experiments conducted in differently coloured lithotypes, Esbert et al. (2003) attributed colour changes (1) in the analysed limestones, to the presence of iron-containing minerals, and namely haematite; (2) in the analysed marble, to the presence of muscovite and/or pyrite bands, surface condition and crystal orientation; (3) in the analysed granite, to the presence of both haematite ($Fe_2O_3$), in the 'pinkish' potassium feldspars, and biotite, which "is the most affected mineral and can reach melting" (2003: 53s). The authors furthermore suggest that a careful colorimetric analysis of the discolouration effect may be used for setting damage thresholds (Esbert et al. 2003).
Gaspar et al. also reported a "severe discolouration" in architectural terracotta samples after laser cleaning, both at 1064nm and at 532nm, making it "unsuitable for terracotta surfaces" (2003: 297s).

Extensive research has been dedicated to the yellowing appearance of whitish stones following laser cleaning, reported in the first years of using the technology (Vergès-Belmin & Dignard 2003). A clear and schematic description of the origins of this yellowing appearance is given by Pouli et al. (2012). Very briefly, some yellowing may occur (1) because the laser cleaning uncovers (pigmented) surface finishes or protectives (historic patinas, e.g. *scialbature* and/or waxy or oily coatings) or naturally acquired patinas (from weathering or bioactivity); or (2) due to an incomplete removal of (pigmented) deposits (e.g. iron-containing particles or air-borne organic residues), including those that migrate into superficial layers of the stone substrate; (Pouli et al. 2012; Siano et al. 2012; Vergès-Belmin & Dignard 2003). In the latter case, yellowing may be attributed to light scattering phenomena in a gypsum-rich surface layer with voids caused by the ablation of (dark) soiling particles (Zafiropulos et al. 2003) or remnants of these particles left behind on the said epigenetic gypsum layer (Vergès-Belmin & Labouré 2005).

Leaving historic or natural patinas behind is generally considered a conservation option and not damage (Delgado Rodrigues 2006), and at least oxalate patinas have been demonstrated as physic-chemically harmless for the stone substrate (Vergès-Belmin & Labouré 2005). As for the incomplete removal of undesirable particles, it is a problem nowadays considered "mostly solved" (Siano et al. 2012: 420) since, in many cases, the yellowing may be avoided by adjusting the laser parameters, including wavelength(s) and pulse duration, and combinations thereof (Pouli et al. 2008; Pouli et al. 2012; Siano et al. 2012). Also, some of this yellowing may be (very slightly) dimmed by the application of cellulose poultices, which are apparently able to remove some coloured particles (Vergès-Belmin & Labouré 2005) or, still, by exposure to UV-B radiation following laser cleaning (de Oliveira et al. 2015).

*(iii) residues of cleaning products left behind*

Chemical cleaners that are absorbed by the substrate may become retained inside the stone (Andrew et al. 1994) – Werner (1989), for instance, reported chemical cleaning residues remaining in cleaned sandstones to a depth of 20mm; the interaction of these reagents with stone components or contaminants may cause undesirable colour variations. When comparing the potential harmfulness of different chemical cleaning agents, Thorn (1993) reported a particularly high sodium deposition in sandstones treated with the AB57® paste (composition in Table 4.1).

On the other hand, acids or alkalis may corrode or dissolve brushing materials, including wire or natural-fibre bristles, thus inducing masonry discolouration (BSI 2000). Likewise, steel wire brushes are generally unadvised for masonry cleaning not only because of their harshness but also due to the high probability of steel fragments left behind later evolving into rust stains (Ashurst, J. 1990).

Poultice materials may also be difficult to eliminate: Vergès-Belmin & Siedel (2005) balance the efficiency of desalination poultices made of mixtures incorporating clays, sand and cellulose against the risks of staining the surface due to the difficulties in removing the poultice in its entirety. This problem may be at least partially overcome by the use of a Japanese paper interface between the surface and the poultice (Snethlage & Sterflinger 2011; Vergès-Belmin & Siedel 2005), a solution that may prove valuable as well when using ion-exchange resins of very fine grain sizes, to avoid residues left on superficial micro-discontinuities (Matteini et al. 1995).

When used on very porous substrates, micro-particle jets can also leave residues of the used particles behind (Alessandrini et al. 1995), causing discolouration. For the same reason, the water used in washing should be checked for the presence of staining contaminants (Slaton & Normandin 2005).

## III. Indirect damage

Indirect damage refers to damage caused by cleaning to elements other than the surface being cleaned or to damage via non-immediate mechanisms; this type of damage may include:

*(i) water infiltrations*

Water infiltrations may cause damage to the building interior in the short and/or long terms. This damage may take the form of water seepage inside the building, with deterioration of interior elements such as "timbers, iron fixings, electrical wiring and internal fixtures and fittings" (Andrew et al. 1994: 47). As John Ashurst remarks, "In old walls, especially those of double skin and rubble fill construction, water from the outside may travel considerable distances before emerging in other parts of the building" (1990: 128).

Water may also accumulate in voids within the substrate, with mobilization of salts (see below), soiling (making it more inaccessible to cleaning), or clays (see below). This accumulation may additionally bring physical damage if the object is exposed to freezing temperatures (see below).

Even mechanically mild cleaning methods such as water mist will saturate walls and may provoke infiltrations, particularly if there are readily accessible points of water entry, such as cracks or open/faulty joints. Given the generally long periods required for cleaning with

nebulized water, Snethlage (2011) advises against its use in buildings holding valuable objects, such as museums and galleries.
It should also be noted that the blockage of gutters or downpipes because of improper disposal of particles used in wet or dry grit blasting (Andrew et al. 1994) may also lead to future water-infiltration damage.

*(ii) salt mobilization by water-based methods*

The mobilization of soluble salts inside the stone may lead to serious mechanical damage caused by the high pressures imposed by salt hydration or crystallization inside the stone pores. Damage will vary depending on (1) which salts are present, with greater damages being caused by the salts with the highest volume changes upon hydration or crystallization; and on (2) the pore size distribution of the stone, since stones with a high percentage of micro-pores are more susceptible to salt damage (Andrew et al. 1994). The combination of salts and moisture is the most serious factor leading to the deterioration of stone (Snethlage & Sterflinger 2011); damage may range from staining, due to salt migration to the surface, to actual mass loss, via the pitting, flaking or powdering of the substrate (Ashurst, J. 1990).
On the other hand, an ill-planned or inadvertent salt removal may cause the disaggregation of substrate material, as pointed out by Biscontin et al.: "In the case of masonry and of structural systems in general, whether in stone or in brick, that are affected by salts either from the outside (aerosol and marine environment, for example) or from the inside (for example, rising damp), it is certainly not convenient to eliminate the salts that are present, which have taken on other functions within the masonry" (1995: 629). Doehne & Price, in turn, stated that "If a limestone is heavily sulphated, the calcium sulphate may be all that is holding it together, and total removal could be disastrous" (2010: 34). An especially striking example of this scenario was reported by Skoulikidis et al., who verified the existence of a 4mm-thick layer of sulphation products covering sheltered areas of the Parthenon marble Caryatids and some other frieze sculptures: "This layer mimics the surface details of the sculpture, in such a way that in some areas we are led to believe, at first sight, that the sculptures are intact in those places", adding that eliminating this layer would cause "an acceleration of the suphation process, since the attack of a «young» surface is always more intense" (1976: 172), along, of course, with the loss of said details.

*(iii) soluble salts formation/increase/deposition*

Cleaning actions may add to the amount of soluble salts present on the object, be it because the method reacts with the substrate and forms new salts, or because it leaves residues behind.
According to Snethlage (2011), part of the sodium sulphate that is formed in the cleaning of black crusts using poultices with sodium salts of EDTA will migrate into the stone; sodium sulphate is a highly soluble salt and post-cleaning extraction with desalination poultices may not be entirely effective. A similar phenomenon is likely to occur with poultices resorting to ammonium carbonate, also used in the cleaning of gypsum crusts, which yield a highly soluble ammonium sulphate as by-product. Again, post-cleaning extraction with desalination poultices may not be satisfactory and the application of barite poultices to resolve the problem by forming insoluble barium sulphate, recommended by Matteini, has proved ineffective below the surface, as reported by Snethlage (2011).
On the other hand, several cleaning methods may leave salts behind as a cleaning residue; these include some biocides (Andrew et al. 1994) and certain particles that may be used in microparticle jets, such as sodium carbonate or bicarbonate.

*(iv) swelling of clay minerals caused by water-based methods*

Clay minerals are the final products of the chemical alteration of silicates and feature a laminar crystalline structure that may swell in the presence of water due to intra- or inter-particle adsorption or absorption (Delgado Rodrigues 2001). These phyllosilicates may be found in any type of stone, igneous, metamorphic or sedimentary, where their water-induced expansion behaviour has the potential to generate relevant internal stresses and result in significant damage. According to Delgado Rodrigues, "[the] type and extent of swelling depend on several factors, namely on the type and amount of clays, on their form of occurrence inside the stone, on the interparticle and interlayer distances of clay particles, as well as on the composition and availability of percolating solutions." (2001: 186)

*(v) frost damage caused by water-based methods*

Frost damage may take place when water trapped inside substrate voids reaches temperatures low enough to promote its freezing and consequent volume expansion; its effects will be enhanced by repetition, i.e., in freeze-thawing cycles.

This trapped-water freezing may ultimately result in material loss via damage mechanisms similar to those caused by salt crystallization (Andrew et al. 1994). Moreover, frost damage will be highly exacerbated by the presence of salts, even if following a slightly different mechanism (Lindqvist et al. 2008). With or without salts, frost damage will manifest predominantly as spalling at surface level and it will generally not imply changes in pore shape, size distribution or total percentage (Lindqvist et al. 2008).

*(vi) promoting of biological growth*

When non-selective cleaning methods are used for the cleaning of biological colonization and or patinas, particularly if these methods are water-based, the re-growth of biological micro-organisms, and specifically algae, may return, often at higher levels than before the cleaning action (Warscheid, Petersen & Krumbein, quoted in Pinna 1995). Other methods that use organic substances, including acids or solvents, may also activate spores and promote the development of fungi (Pinna 1995).

On the other hand, residues of cellulose fibres used as poultice media may promote mould growth (Vergès-Belmin, Heritage & Bourgès, quoted in Gerrow et al. 2014). The possibility of coloured algae development has also been noted as one of the problems that may arise from water cleaning, as is the development of dry rot following water infiltrations (Ashurst, J. 1990).

### 5.2.4. Identification of the consequences

As Nanda et al. pointed out, "risk needs to be managed based on the values of the system that created the risk, and the cultural property in question" (2001: 72). Analysing the consequences of a cleaning intervention should always refer to the dimensions that any conservation action aims at safeguarding, i.e., the significance, authenticity and integrity of the object. The consequences of damage occurring following a cleaning intervention (or any conservation action) are:

1. reducing the **significance** of the cultural object, i.e., lowering or causing the loss of one or more of the values of the object;
2. reducing the **integrity** of the cultural object; integrity is first and foremost connected to the fabric (UNESCO 2015);
3. compromising the **authenticity** of the cultural object: significance depends on the authenticity and, (at least) in Western cultures, authenticity is closely related to the fabric, which may constitute the most relevant source of information about the object.

From here, it follows that the seriousness of the consequences varies positively with the significance, authenticity and integrity of the object.

Value "is an extrinsic property that cannot be directly detected by the senses, it does not exist without a social context. The value of an object can only be derived by comparison with the values of other objects or actions" (Ashley-Smith 1999: 82), and thus significance lends itself to being ascribed degrees depending on (i) the dimension of the social group for whom the object is important and (ii) the overall importance of the object for said social group. These importance rankings are typically distinguished in official heritage protection listings (see Section 2.1.1 and Appendix B), where increasing degrees of legal protection and restrictions are progressively imposed upon objects considered important for correspondingly larger communities.

Authenticity and integrity are, respectively, a significance requisite and a qualifier that, as pointed out earlier for Western cultures, are largely related to object features such as the historicity of the fabric and its completeness, respectively. Given their nature and definition, they are considered here as conditions for the maintaining of the significance of the object. Therefore, the impact on both 'authenticity' and 'integrity' is considered as included in the significance assessment.

Cleaning actions take place on the surface. In many, if not most, instances, surface features are the most valued by its stakeholders, given that "the surface is the interface […] between the object and its users" (Ashley-Smith 1999: 100); on the other hand, the surface is also the interface between the object and its surrounding environment – e.g. decorative details generally embody aesthetical values, among others, but may also "serve a utilitarian purpose in controlling the flow of water over the surface of a building" (Olley et al. 1989: 668). Hence, and not disregarding substrate analysis, a special attention should be dedicated to the specific roles of surface features on the significance, authenticity and integrity of the object.

## 5.3. *Risk index analysis*

*The results of the scientific research will only be valuable if they are formulated into simple and feasible rules and are disseminated to everybody involved in conservation practice.*

G. Zacharopoulou (1998)

This section is dedicated to the application of the risk index method for the analysis of the risks involved in built heritage cleaning. Given the scope and goals of the analysis, along with the identification and characterization of damage mechanisms, scenarios and consequences, developed in the previous sections, it is now possible to propose risk factors and the corresponding parameters that will serve to describe them. A rating system will be defined for these parameters, along with the rules for the obtaining of the risk index that will permit comparing different cleaning options and serve as an input for the ensuing risk evaluation, presented in Chapter 6. Some considerations on the impact of the different factors upon the final risk index are additionally highlighted.

### 5.3.1. Selecting risk factors and parameters

Two types of risk factors should be considered in a risk analysis: those influencing the *likelihood* and those influencing the *consequences* of damage occurring. Considering the identification of risks proposed earlier in this chapter, the following factors were selected as having a decisive role in the likelihood of occurrence of cleaning-induced incompatibilities: the *Vulnerability of the surface*; the *Aggressiveness of the method*; the *Synergetic effects between the substrate and the method*; and the *Quality components*. Likewise, the *Impact on the significance of the object* was selected for the assessment of the consequences of damage occurring.

The rating system of the selected risk factors should be based on their influence in the overall risk, both causes and consequences. Therefore, this influence is briefly summarized below for each different factor, based on the risk identification carried out.

**Vulnerability of the surface**

The vulnerability of the surface to a cleaning action will depend, to a certain extent, on which kind of method is used. Nevertheless, it is possible to say that, in general, the (mechanical) resistance, the conservation condition, the chemical/mineralogical composition and the water behaviour will be relevant parameters in predicting the likelihood of damage to a surface subjected to a cleaning action. Hence, to have an at least basic knowledge of the type of substrate in question is of fundamental importance. For some stone types, this should imply having a notion of the porosity values: the correlation between porosity and mechanical resistance, at least in carbonate stones, has long been demonstrated (Delgado Rodrigues 1988), not to mention the role, highlighted earlier, that porosity plays in superficial dissolution

mechanisms (Van Den Eynde et al. 2013); for granites, slight differences in porosity imply large variations in the mechanical resistance of the stone (Delgado Rodrigues 1978).
Stone open porosity values may be determined with a simple laboratory test, and the sole difficulty will most likely reside in the obtaining of the necessary samples.

**Aggressiveness of the method**

The aggressiveness of a given method is mostly influenced by the controllability it allows the operator. Even for knowledgeable and skilled executants, some methods may pose relevant controlling difficulties, which become particularly serious in the case of methods that apply high energy levels but do not allow for an adequate degree of selectivity. Wet or dry particle and micro-particle jets are typical examples of methods that may easily abrade more material than intended, as underlined earlier in this chapter, becoming more aggressive as the energy levels used increase, e.g. by using higher pressures, denser particles, incorrect impact angles or smaller nozzle diameters; strong acids and alkalis are also potentially very harmful cleaning agents, since neutralization is virtually unachievable once the solutions penetrate into the substrate. Mechanical hand tools such as soft brushes and rubbers are examples of methods that are relatively mild because of the high controllability they allow the operator; nevertheless, scalpels, chisels or harsher brushes are potentially more damaging, controllability notwithstanding. In contrast, the selectivity that laser cleaning generally allows in the removal of dark films from white surfaces lowers its aggressiveness, even though high energy levels are employed.

**Synergies between the substrate and the method**

In the current context, synergies define specific substrate-method interactions that cause damages to a greater extent than the ones that would be induced by different combinations. These interactions include the use of weak acids in carbonate stones, as opposed to the use of weak acids in siliceous stones; the use of water methods in substrates with clay minerals and/or salt-laden walls, since either (or both) may play an active role in several degradation mechanisms when in the presence of water, but will not manifest if mechanical methods are applied; or the employing of large amount of water in objects with very permeable construction materials.

The following tables schematically describe the incompatibility risks identified in the previous section by displaying these different factors against the likelihood of their inducing each specific type of damage. These tables should allow for the building of an appropriate rating system.

**Table 5.2:** Summary of the factors influencing the **likelihood** of occurrence of **mass loss**

| Factor/parameter | More likely | Less likely |
|---|---|---|
| Surface vulnerability | | |
| Surface resistance | • Very low resistance;<br>• High porosity values, e.g.:<br>Granites > 2%<br>Sedimentary stones > 15% | • Very resistant surfaces;<br>• Very low porosity values, e.g.:<br>- Granites <2%<br>- Sedimentary stones <5% |
| Surface condition | • Surfaces with generalized degradation features and relevant mass losses (actual or potential). Detachment of scales, cracks and powdering may occur. | • Smooth surfaces with no decay in progress. |
| Method aggressiveness | | |
| Controllability/ potential of damaging energy | • Wet or dry particle or micro-particle jets at high pressures (>0.5MPa) and/or otherwise inadequate operating parameters; | • Neutral reagents; organic solvents; non-ionic surfactants;<br>• Laser below the ablation threshold;<br>• Nebulized water with no brushing; |

| | | |
|---|---|---|
| | • Strong acids (pH<5) or alkalis (pH>11);<br>• High-pressure (>0.5MPa) water jets;<br>• Laser above the ablation threshold. | • Poultices. |
| Synergies | | |
| Substrate components sensitive to chemical methods | • Carbonates when using acids;<br>• High silicate content when using strong alkalis;<br>• Presence of Ca, Mg and/or Fe when using chelates. | • Using weak acids and bases in silicate and carbonate rocks;<br>• Water-based methods in clay-free and salt-free substrates. |
| Surface texture sensitive to mechanical actions | • Polished surface;<br>• Very friable surfaces;<br>• Cut and smoothed surface. | • No surface finishing. |
| Substrates sensitive to steam cleaning | • Substrates with a high percentage of anisotropic minerals;<br>• Polymineralic substrates. | – |

**Table 5.3:** Summary of the factors influencing the **likelihood** of occurrence of **discolouration**

| Factor/parameter | More likely | Less likely |
|---|---|---|
| Method aggressiveness | | |
| Controllability/ Potential of damaging energy | • Laser used above the discolouration threshold;<br>• Organic solvents;<br>• Methods leaving residues behind: chemical cleaning with or without poultices, particle jets. | – |
| Synergies | | |
| Sensitive substrate components | • Chemical cleaning of substrates with iron and/or manganese compounds;<br>• Laser cleaning of substrates with iron compounds. | – |

**Table 5.4:** Summary of the factors influencing the **likelihood** of occurrence of **indirect damage**

| Factor/parameter | More likely | Less likely |
|---|---|---|
| Surface vulnerability | | |
| Absorption properties | • Highly absorbent surfaces;<br>• Presence of open joints. | – |
| Method aggressiveness | | |
| Type of reagent | • Methods using running water;<br>• Methods using acids and alkaline cleaners;<br>• Sodium carbonate or bicarbonate jet particles. | – |
| Synergies | | |
| Water-sensitive substrate components | • High salt content and/or clay mineral content. | • Low salt and/or clay mineral content. |
| Environmental temperatures | • Temperatures promoting freeze-thawing cycles when using water- | – |

| | | |
|---|---|---|
| | based methods. | |

**Quality components**

As discussed earlier, any risk caused during a heritage cleaning intervention will have been caused by human or equipment errors, including misjudgements or limitations of the resources made available. It was already amply mentioned that the skills and training of the operators in charge of the conservation actions are determinant for the final outcome of the intervention; but other professionals are at play that decisively contribute for the conservation process, and namely those responsible for the planning and control stages. On the other hand, the time and budget allocated for a given intervention may impose relevant restrictions on the cleaning process. Generally speaking, the tender value will reflect the aversion to risk of the site authorities, with higher public tender values corresponding to projects which are more defensive and predict contingency costs (Caldeira 2005).

The factors listed above – vulnerability, aggressiveness, synergies – may be classified as 'hard factors', since they deal essentially with given features, either of the object or of each specific method. The quality components, however, are principally related to the human resources responsible for the various steps of the intervention, and their ability to plan for, perform in and respond to the different issues raised by the cleaning actions; they are therefore more appropriately considered as 'soft factors'. Another way of putting this is to say that vulnerability, aggressiveness and synergies are technical risk factors, whereas the quality components correspond to project contracting and management factors.
These components may influence the likelihood of damage occurring regardless of the specific type of damage considered; their potential impact is summarized in the table below.

**Table 5.5:** Summary of the influence of **quality components** on the likelihood of occurrence of **any type of damage**

| Factor/parameter | More likely | Less likely |
|---|---|---|
| Quality components | | |
| Project and logistics | • None or poor significance or deposit impact assessments;<br>• Unjustified, undefined or Ill-defined target surface;<br>• No conservation concept;<br>• Insufficient budget and/or time resources. | • Thorough significance and deposit impact assessments;<br>• Scientific consultation;<br>• Adequate planning, budget and calendar. |
| Conservation team | • None or inexperienced conservator-restorers supervising the project;<br>• Inadequately trained or inexperienced operators; | • Adequately trained conservator-restorers in the team;<br>• Adequately trained and skilled operators overseen by conservator-restorers. |
| Control team | • Untrained/inexperienced supervisors;<br>• None or poorly defined reference/target surface. | • Adequately trained supervisors;<br>• Clearly defined reference surface. |

**Damage consequences – Impact on Significance**

To ascertain the consequences of cleaning damage occurring entails an in-depth knowledge of how the different material features impact on the significance, authenticity and integrity of the object. Even though the values of the object are a social construct that is liable to change in time, the impact on significance should be considered a 'hard' factor, i.e., a given, since the planner will, in principle, have little bearing on the significance bestowed upon the object in the specific moment when the cleaning will take place.

Within the same object, different areas of significance may (and probably will) coexist. For instance, the loss of a decorated surface will commonly – though not necessarily – have a greater impact on the significance of the object than the loss of a plain undecorated surface. The impact on authenticity is not clear cut either; for instance, the loss of a surface holding evidence on which some (or all) of object values are based, e.g. tool marks or a signature, may potentially be more serious than the loss of an undistinctive decorative pattern.
The question that needs answering, for each area of a different significance within a given object, is thus 'How gravely would significance/authenticity/integrity be affected by the loss/degradation/discolouration of this surface area?'

On the other hand, not all objects bear the same significance: "artefacts vary enormously in value" (Michalski 1992: 241), and/or the stakeholder groups valuing them may be of different dimensions. Judging on the importance of a given object may be made easier by considering its presence in or absence from official heritage protection listings. However, the object may be of extreme importance to a social group not necessarily represented in such heritage listings, and therefore a significance assessment should always carefully consider the object stakeholders.
Also, as seen earlier, within heritage listings, objects may have different degrees of significance ascribed to them; such information, if available, may also be helpful in the assessment of damage consequences, providing attention is given to eventually misrepresented stakeholder groups. Incorporating significance appreciations ensuing from heritage listings as a parameter in a risk index method was also proposed by Watts & Kaplan (1998) for fire risk assessments; the authors thus further included judgements on the quality and expendability of building and contents, respectively.
A brief description of the influence of the two levels of significance – general and surface-specific – on the consequences of damage is summarized in the table below.

**Table 5.6:** Summary of the influence of **significance** on the consequences of damage occurring

| Factor/parameter | More serious | Less serious |
|---|---|---|
| Impact on significance/authenticity/integrity | | |
| Heritage listing | • Listed as national/world heritage > regional > local heritage;<br>• Unlisted object with values held very strongly by a given community. | • Not listed.<br>• Few concerned stakeholders and/or stakeholders showing little interest. |
| Surface relevance | • Surface features are crucial for the understanding and valuing of the object. | • Surface features are not particularly important or relevant for the understanding and valuing of the object. |

These summary tables allow not only distinguishing more clearly which parameters should be considered in a cleaning risk analysis, but also provide an insight on how the parameters should be rated in a way that matches their contribution to the overall risk; the developed incompatibility risk rating systems are presented in the next section. It should be noted that the indicators and rating tables shown below correspond to the final version of the assessment procedure[38], i.e., after the Delphi panel scrutiny. Hence, both parameters and their respective ratings incorporate the opinions and insights of the convened conservation specialists.

### 5.3.2. Cleaning incompatibility risk factors & rating tables

As seen earlier, risk is defined as the multiplication of the likelihood of damage occurring and the consequences of that occurrence. In heritage cleaning interventions, different risk factors influence both classes in this equation, which were divided into 'hard' and 'soft': the 'hard'

[38] The initial version of the assessment procedure, i.e., the one first sent to the Delphi panel for evaluation, is presented in Appendix D – First Round – Document 1.

factors correspond to items that may be parameterized and semi-quantitatively evaluated, whereas the ‘soft factors’, due to their strong human component, are more difficult to translate into gradable parameters.
‘Hard’ factors are dealt with firstly: (A) the vulnerability of the target surface to cleaning; (B) the aggressiveness of the cleaning method; (C) the synergistic effects that may occur with specific method/substrate combinations, leading to a risk increment; and (D) the impact on the significance of the object. The first three factors are considered to influence the likelihood of damage occurring (L), whereas the consequences of such damage are assessed via the evaluation of the ensemble of values, i.e. the significance, of the object (D). Analytically, using a simple aggregation rule:

$$IR = L \times D$$

Where:
IR = Incompatibility risk
L = A×B×C (Likelihood of damage)
D = Consequences of damage
Computing the different factor assessments should therefore permit the planner to obtain an insight on the level of risk involved in the choice of each cleaning method.
The ‘soft factors’ are related to components such as ‘conservation team skills’ or ‘control’, and are dealt with in the ‘Quality components’ section below. These ‘soft factors’ are sources of risk that also influence the likelihood of damage occurring, and their effect must be acknowledged, even if their assessment is somewhat less defined.

### *Factor A: Vulnerability to cleaning*

When starting the process of assessing the incompatibility risk of a cleaning intervention, the vulnerability of the target surface should be analysed firstly. Both the type and, where applicable, compactness (using open porosity as a parameter) of the substrate should be determined, and its surface condition should be assessed in terms of resistance to a cleaning intervention. Surface decay signs, and particularly actual or potential material losses, from small particles to large scales, including particle adhesion and cohesion, should be analysed in terms of severity of decay and susceptibility to external actions.
Table 5.7 provides indications on the assessment of the target-surface vulnerability, where lower ratings are to be attributed to stable surfaces, while the higher ratings should correspond to more vulnerable surfaces. After identifying the substrate type (first column), a value should be chosen within the proposed ranges that matches the substrate surface condition – higher values should correspond to increasingly more fragile conditions. For substrates not explicitly considered, it is suggested that the users try to find appropriate ratings based on similarities of their substrate to any of those identified here. A set of ‘Guidelines’ is included to provide further assistance.

**Table 5.7: Factor A – Vulnerability to cleaning**. Vulnerability should be rated according to substrate type and target surface condition; for any given substrate, its susceptibility to damage increases with the seriousness of surface decay.

| Parameters – Substrate types | Ratings (1 2 3 4 5) |
|---|---|
| Granites and gneisses with porosity <2% | 1–5 |
| Granites and gneisses with porosity > 2% | 2–5 |
| Marbles | 2–5 |
| Dense limestones and sandstones (Porosity <5%) | 1–5 |
| Medium sandstones **(*)** (5%< Porosity <15%) | 2–5 |
| Medium limestones (5%< Porosity <15%) | 3–5 |
| Very porous limestones and sandstones **(*)** (Porosity >15%) | 4–5 |

| | |
|---|---|
| Slates and other low grade metamorphic rocks | |
| Volcanic tuffs | |
| Basalt, gabbro and similar rocks | |
| High grade metamorphic rocks | |
| Porphyry | |
| Brick masonry | |
| Ceramic materials | |
| Concrete | |
| Mortars and renders **(**)** | |

**(*)** Sandstones with siliceous cement may be very resistant. In such cases, vulnerability may start at very low values of 1 or 2.
**(**)** Mortars and renders made with hydraulic binders may be very resistant. In such cases, vulnerability may start at very low levels of 1 or 2.
**Guidelines:**
- The probability of damage increases with surface decay: for each substrate type, within its respective bar, lower values correspond to sound substrates and higher values should be chosen for surfaces showing progressively more serious signs of decay.
- When the substrate exhibits different surface conditions throughout its extension, different representative assessment areas should be defined, since different assessments must be performed.
- Other plutonic rocks, e.g. diorites and other granitoids, should be analysed similarly to "Granites and gneisses".
- When assessing surfaces with multiple materials, such as mosaics, tile pieces or stone intarsia, refer the assessment to the frailest element.

Figure 5.2 shows details from a 19th century triumphal arch, built in a very dense limestone, presenting areas of different vulnerabilities, either due to slight compositional variations in the materials used, either because of differences in the exposure to weathering agents. From this example, it becomes clear that the same method would imply different likelihoods of damage in each of those four distinct surfaces. Planners resorting to the procedure are encouraged to build up their own benchmarks to apply in each practical case.

**Figure 5.2:** Heavily soiled surfaces in a monumental arch, showing a dense limestone with different vulnerability ratings. *Top left: a very stable surface (A=1); top right: a very stable surface with incipient decay signs (A=2); bottom left: moderate decay features and interaction of the black crust with the substrate (A=3); bottom right: evident decay signs and active material losses (A=4).* (Images courtesy of José Delgado Rodrigues)

### *Factor B: Aggressiveness*

The cleaning method is then ranked in terms of its aggressiveness, i.e., potential to inflict damage regardless of the substrate where it is applied. The aggressiveness of the method depends on the controllability allowed to the operator; and on the potential of damaging energy that is forced upon the substrate. Since this assessment intends to rank the baseline risk that the method involves, it should be presupposed that the method is handled by a knowledgeable operator; uncertainty about the operator skills must be considered in the end of the assessment (see 'Quality components'). Additionally, attention is drawn to the fact that, if using a combination of methods, (full) separate assessments are necessary.
The proposed aggressiveness assessment is described in Table 5.8.

**Table 5.8: Factor B – Aggressiveness.** Each method should be rated according to the controllability it allows for a knowledgeable operator and/or the potential of damaging energy applied on the substrate.

| Parameters | Ratings (1–10) |
|---|---|
| **Mechanical methods** | |
| Hand tools (scalpels, brushes, chisels and similar) | 1–6 |
| Particle jet : - spherical micro-particles (<0.1mm) set to low pressure (<0.05MPa) | 3.5–4 |
| - intermediate particle and pressure values – lower ratings for: - low density particles; - round shapes; - smaller sizes; softer particles; - lower pressures. | 4–9.5 |
| - high pressures (> 0.5MPa) (particles of any size or shape) | 9.5–10 |
| Micro-hammer / pneumatic tools / rotary tools | 4–6 |
| Ultrasounds | 3–6 |
| **Chemical methods** | |
| Neutral reagents (6<pH<8), incl. organic solvents | 1–2 |
| Weakly acidic (5<pH<6) or alkaline (8<pH<11) reagents | 2–3 |
| Strongly acidic (pH<5) or alkaline (pH>11) reagents | 8–10 |
| Chelating agents | 3–5 |
| **Water-based methods** | |
| Without pressure (mist, sprinkling, without brushing), poultices | 1–2 |
| Without pressure (mist, sprinkling) with brushing | 2–4 |
| Water jet: - low pressures (~0.2MPa-0.3MPa) | 3–5 |
| - intermediate values | 5–7 |

| | |
|---|---|
| - high pressures (>0.5MPa) | |
| Steam jet | |
| Wet grit blasting | |
| LASER | |
| Below ablation and discolouration thresholds | |
| Above ablation or discolouration thresholds | |

**Guidelines:**
- Methods must be considered alone; if planning to use a combination of methods, separate assessments are required.
- The likelihood of damage decreases with the controllability of the method and increases with its potential of damaging energy. Higher values should be chosen for methods that are increasingly more difficult to control and/or that are applying more intense energies (e.g. larger, denser, harder or more irregular particles, higher pressures, smaller nozzle diameters; higher or lower pH values; higher concentrations, etc).
- When assessing cleaning agents, and particularly chemical cleaners or jet methods, remember that residues left on the substrate, causing staining or soluble salt formation, are also damaging, and the rating should reflect this. Be especially attentive when planning to use aromatic solvents, alkaline cleaners, surfactants or sodium carbonate or bicarbonate jet particles.
- Poultice media (e.g. clay, paper fibres or latex dispersion) are not specified here; the user should refer to the cleaning solutions used (water or chemical cleaning). When the risks associated to poultice cleaning are mostly related to the left residues, the use of a Japanese paper interface will lower them.
- Dry ice blasting should be considered as a micro-particle jet (where the particles are solid $CO_2$).
- In jet cleaning with particles or micro-particles, low densities chiefly correspond to organic substances and are generally below 1g/cm$^3$.
- Bacterial and enzymatic cleaners should be considered as chemical cleaners.
- When analysing water based methods requiring long contact or dwell times (e.g. poultices) consider the possible induction of biological growth.

#### *Factor C: Synergies*

Once the absolute vulnerability of the surface and the absolute aggressiveness of the method are evaluated, it is necessary to analyse the synergetic effects that may arise from different substrate/method combinations. Indeed, some features of a given substrate may cause it to be particularly harmed depending on the method and circumstances of its use; these specific combinations will increase likelihood of damage, but would remain unrevealed without this synergetic factor. For instance, a salt-laden wall may be seriously affected by a water-based method, whereas a purely mechanical method would cause no damage increment in that particular regard. Likewise, an acidic cleaning solution will not have as much damaging consequences on a silicate-based stone as it will on a carbonated stone or render. Also, any method involving mechanical actions, when used on a friable surface, will lead to a higher likelihood of damage than the one predicted by its aggressiveness rating.
The assessment of the synergetic effects should bear in mind that damage may supervene after a certain delay (water seepage, salt migration, etc.).
It was considered that substrate/method synergies have a risk amplification effect and therefore should be rated between 1 and 2; for example, a rating of 1.2 translates into a final risk increment of 20%. Table 5.9 lists the proposed risk ratings to evaluate these interactions.

**Table 5.9: Factor C – Synergies**. Synergies may occur whenever there is interaction between the substrate and the cleaning method, or an increment of collateral risks.

| Parameters | Increments | |
|---|---|---|
| | 1 | 2 |
| Chemical methods | | |
| Causing chemical degradation / decomposition / staining / formation of soluble salts. Examples: | | |

| | |
|---|---|
| - acids on carbonated substrates<br>- strong alkalis on siliceous substrates<br>- chelating agents on substrates containing Mg or Ca<br>- mobilization of iron compounds | |
| **Any method requiring water** | |
| On highly absorbent / permeable construction materials | |
| On substrates with soluble salts | |
| On substrates with clay minerals | |
| On substrates sensitive to temperature fluctuations when using steam (e.g. marbles) | |
| On substrates sensitive to environmental freezing temperatures | |
| **Any method** | |
| On polished surfaces | |
| **Any method with a mechanical action** | |
| On very decayed and friable surfaces | |

**Guidelines:**
- The probability of damage increases with the interaction between substrate and cleaning agent.
- Polished surfaces may be less vulnerable to mass loss, but any slight modification is easily perceived, resulting in higher visual impacts.
- Methods with a mechanical action include all methods that operate through impact forces, such as wet and dry brushing, scalpels and other hand tools, and also wet and dry particle jets.
- If the substrate/method combination does not configure the existence of a synergy, then C=1.
- The circumstances listed are cumulative; if more than one specific circumstance coexists, then the respective parameters should be rated and multiplied.
- For instance, the chelating agent $Na_2EDTA$ may form an acidic solution and, when applied on carbonate stones, should be assessed considering the pH as an added synergy (e.g., C=1.5x2).

### *Factor D: Impact on Significance*

Finally, the seriousness of the consequences of damage occurring during cleaning should be assessed. This means asking the stakeholders involved: "How much would the damage of the surface material affect the significance of the object?", or, in other words, "How relevant is the surface for the overall significance of the object?" It is proposed that this assessment may follow the criteria listed in Table 5.10, although conducting a lengthier analysis beforehand is strongly recommended.

Objects are divided in listed and unlisted, with higher ratings assigned to the former. While acknowledging that many important objects may not be officially listed, it is considered that, among the vastness of objects with cultural significance, some have a higher significance than others, and their listing status was used as criterion for lack of a better option. One should never forget, however, that all objects that come under the current analysis hold cultural significance to some extent, since this method is specific for heritage cleaning. Furthermore, the criteria described in Table 5.10 are indicative, and the planner's judgement is advised for cases where values are very high and/or held strongly by a given community, even though the object is not officially listed.

Within each category of objects (listed/unlisted), it is still important to assess how relevant are the surfaces for the overall significance. This may be judged by considering the effects of the loss of surface material: generally – though not always – losses will have a greater impact on significance if the surface is decorated, or has a particular texture, than if it is a plain building block with no particular surface features. Again, planner's judgement and stakeholder consultation are the operating instruments and both should aim at obtaining a significance rating for the object under assessment.

**Table 5.10: Factor D – Impact on significance**. Assessing the consequences of damage means considering how valuable the surfaces are.

| Parameters | Ratings |
|---|---|

| Surface relevance | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Listed or equivalent objects** | | | | | |
| Surfaces of lower relevance | | ■■ | ■■ | ■ | |
| Surfaces of higher relevance | | | | ■ ■■ | ■■ |
| **Unlisted objects** | | | | | |
| Surfaces of lower relevance | ■■ | ■■ | ■ | | |
| Surfaces of higher relevance | | | ■ ■■ | ■■ | |

**Guidelines:**
- the seriousness of damage consequences increases with the relevancy of the target-surface materials for the overall significance of the object.
- formal aspects such as the presence of sculpted work, carvings or other decoration patterns are generally associated with higher relevance; plain ashlars or rubble masonry may be comparatively (though not necessarily) less relevant for the significance of the object.
- areas of different relevance may coexist in the same object (e.g. pavements and portals); if this is the case, representative areas must be chosen and assessed separately.
- when the surface is part of an ensemble, the impact on the ensemble significance may need to be considered.

Figure 5.3 illustrates how different degrees of significance can be met in a single monument.


**Figure 5.3:** Differences in significance within a single (listed) monument The stone surfaces carved by a renowned Portuguese sculptor were given the highest significance, while raw surfaces in the basement were given lower values. P1: Pavement and basement blocks (D=2); P2: Undecorated blocks in the plinth and fence pillars (D=3); P3: Decorated surfaces (D=5). (Image courtesy of José Delgado Rodrigues).

### *Quality components*

Table 5.11 shows planning Quality components that may help configure an optimal intervention scenario or, quite the opposite, cause the whole intervention to irrevocably fail. Unlike the previously discussed factors, which were rated according to given features of the object or cleaning method, classifying the quality components depends on if and how they are planned.

The consideration of these components in this section and not as 'hard' factors derives from the evident difficulty on finding the appropriate parameters to rate them properly. These are strongly human-dependent parameters that are best considered as 'soft' parameters, for whose analysis a careful scrutiny is necessary. A careful and considered planning may limit the risk values to those reached with the 'hard' factors, whereas an ill-considered or absent planning will increase the cleaning risks involved by the multiplication factors proposed in Table 5.11. Any doubts and insufficiencies that the planner may identify regarding the means and resources available for the cleaning intervention should be given a rating here, to be multiplied by the values obtained in the previous sections.
In this perspective, these 'quality components' are to be considered as risk factors that will increase the likelihood of damage occurring.

**Table 5.11: Quality components**. These are risk-multiplying factors whenever they are neglected.

| |
|---|
| Preparatory – may increase final risk by a factor of **1 to 3** |
| Significance analysis |
| Deposit impact assessment (consider historical/aesthetical/chemical/physical/social/other impacts) |
| Documentation of the conservation condition (to have such a documentation will lead to an easier and more correct assessment of Vulnerability) |
| Defining, characterizing and justifying the cleaning level (*) |
| Required team skills – may increase final risk by a factor of **1 to 5** |
| Adequacy of operators training and experience |
| Experienced conservator-restorers integrated in the organizing and execution teams |
| Adequacy of the team structure |
| Logistics – may increase final risk by a factor of **1 to 3** |
| Adequacy of time and budget |
| Adequacy of the tools, instruments and products available |
| Adequacy of equipment and other supporting means |
| Control – may increase final risk by a factor of **1 to 2** |
| Adequacy of the controlling methods (e.g. timely definition of reference surfaces) |
| Adequacy of the controlling agents |

(*) in cases beyond simpler situations, cleaning tests are advisable at this stage.
**Guidelines:**
- to know exactly what must and must not be removed is crucial; it entails not only a significance analysis, but also how the deposits impact on that significance, in the short and in the long run; future uses must be considered.
- requiring adequately trained and experienced professionals, including conservators-restorers in key organization and execution positions, and ensuring adequate means and team structures are all sine qua non conditions for accomplished cleaning interventions.
- a well-defined and characterized reference surface that will aptly function as a control tool, and was previously agreed with the contractor; as well as adequately trained control professionals, are essential for a satisfactory result.

One final remark should be made about the weigthing of the different factors: differences in the rating scales correspond, in practice, to differences in the relative importance of the factors. This means that, for instance, the Quality component 'Control' has less impact on the final risk value than the 'Required team skills'; and that the Aggressiveness factor weights twice as much as the Vulnerability factor; and that the Synergies are, as mentioned, viewed as risk amplifiers. This agrees with the fact that both the Vulnerability and Impact on Significance factors are, in practice, a given – it is not possible for the planner to change them. Planner's choices regarding the reduction of risk are limited to the cleaning methods, i.e. Agressiveness and Synergies, and Quality components. This is dealt with more in detail in the next chapter.

# 6. (In)compatibility risk evaluation of built heritage cleaning

*Preservation is then* [when taking a risk management approach] *the cost-effective reduction of the total of all predicted risks.*

R. Waller & S. Michalski (2004)

Risk assessment, as seen, entails not only a risk analysis, but also its ensuing risk evaluation. Risk evaluation is the phase where decisions on the acceptability or tolerability of risk are made by juxtaposing the levels of risk obtained via risk analysis with priorly established risk criteria. The results of risk evaluation will be the input for the remainder of the risk management process, including the treatment, control and monitoring of the assessed risks. These stages of risk management will not be dealt with here, although some insights on risk minimization decisions are hinted at in the analysis below.

## 6.1. Levels of risk

Following the incompatibility risk assessment procedure allows for the obtaining of partial indices – for the vulnerability of the surface, the aggressiveness of the method and the surface-method interactions, and for the seriousness of the consequences in case of damage caused by the cleaning method; additionally, indices for quality components may also be estimated. Once the partial indices are obtained, a global risk index may be gained from multiplying the partial indices, which corresponds to the computing of the probability of occurrence and the seriousness of consequences, i.e., calculating risk.
Nevertheless, it may be useful to distinguish between a likely but not very serious damage from an unlikely but potentially severe damage and thus, in such cases, resorting to a risk matrix is recommended (Caldeira 2005). A risk matrix is a likelihood-consequence matrix where the several strategies (or, in the present context, cleaning options) may be plotted and compared in terms of risk severity; the number of likelihood and/or consequence categories on the risk matrix will depend on the needs of the analysis.

Risk equals the product of the likelihood and the consequences of damage occurring. In this analysis, factors A, B and C are related to the likelihood of damage occurring, whereas factor D assesses its consequences.
The assessment of factors A through D should allow the planner to verify where a given object/cleaning method combination stands – qualitatively, or semi-quantitatively – in terms of its risk. It is proposed that the likelihood factors (A, B and C) are aggregated via a simple multiplication and that the obtained value is then cross-checked with the consequence factor (D) in the cleaning risk matrix proposed in Table 6.1. For example, in a situation where a non-significant high density stone surface in a sound condition is cleaned with water under high

pressure, then: A=1; B=10; C=1; which means that L=10. For D=1, the cleaning risk is 'very low'; for a significant surface (D=5), however, the risk would be 'very high', as the potential loss of value is greater.

**Table 6.1:** Cleaning risk matrix proposal

| Risk | | Consequences (D) | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | **Negligible** | **Moderate** | **Serious** | **Very serious** | **Catastrophic** |
| **Likelihood (L=AxBxC)** | **Very high** L≥40 | Low | Medium | High | **Very high** | **Extreme** |
| | **High** 20≤L<40 | Low | Medium | High | High | **Very high** |
| | **Moderate** 10≤L<20 | Very low | Low | Medium | High | **Very high** |
| | **Low** 5≤L<10 | Very low | Low | Low | Medium | High |
| | **Very low** L<5 | Very low | Very low | Low | Low | Medium |

In simple terms, this can be considered as a 'hard' matrix, meaning that, for a given substrate, the cleaning risk cannot be lowered unless the cleaning method changes. Therefore, risks more serious than 'medium' should immediately trigger the need for a more careful consideration of the cleaning method; reassessments with alternative methods should be tried to see if the risk involved may be lowered. Nevertheless, for the 'soft' factor, the Cleaning Risk Matrix classifications may still be used as a reference once the likelihood (AxBxC) is multiplied by the quality component values obtained, and then cross-checked with the consequences (D).
When no feasible alternative is foreseen for the method under analysis, risk-minimizing actions should be considered, such as reducing the concentration and/or dwell time of an acidic solution or chelating product; interposing Japanese paper when using poultices (Vergès-Belmin & Siedel 2005); or pre-consolidating the surface (as reported, for instance, by Wheeler et al. (1984)).

With a proper assessment of the likelihood factors and taking into consideration the significance of the surfaces in question, the user will end up with a point in the Cleaning Risk Matrix. It is now relevant to be able to move inside this matrix and to realize how practical information can be extracted from it.
In Figure 6.1, a detail of a XVI century façade is used to illustrate how to handle the risk matrix in the search for optimizing operational conditions. The example starts with the use of nebulized water, one of the mildest available cleaning methods, which at a first glance could be considered adequate to clean this object. The risk assessment, taking into consideration the high vulnerability of the concerned surface and the existence of synergies – for the use of water and for the application of mechanical action when brushing – leads to a risk evaluated as "Extreme", given the computed likelihood of damage (≥40) and the high significance of the object. A possible alternative with ammonium carbonate poulticing would reduce the risk from "Extreme" to "Very high", which still functions as a serious warning to the planner. The use of laser cleaning, applied below ablation and discolouration thresholds (B=1), would probably be the only feasible alternative for this delicate case.

**Figure 6.1:** Detail of a highly decorated XVI century portal listed as Spanish National Heritage (D=5). The portal was carved in a porous dolostone and its state of decay suggests a high vulnerability (A=5). From these departing conditions, a hypothetical cleaning with nebulized water and brushing could mean: an aggressiveness of B=3; a synergy of C=1.5 for the use of water; and a synergy C=2 for the use of mechanical action, leading to a risk likelihood of 45 and an overall risk classifiable as 'Extreme'. To reduce the risk, an alternative with ammonium carbonate poultices with: A=5; B=2.5; C=1.5, would be 18.75, a substantially lower but still 'Very High' overall risk. Laser cleaning, applied below ablation and discolouration thresholds (B=1), would keep the risk at 'Medium/High'. (Image courtesy of José Delgado Rodrigues)

Figure 6.2 shows how the surfaces illustrated in Figures 5.2, 5.3 and 6.1 fall into the Cleaning Risk Matrix; the positions of the symbols chiefly correspond to the numbers given as examples in the captions of each figure. The circles representing the surfaces in Figure 5.2 are placed along the same column, because they were all assigned the same significance (D=4). Considering, for instance, cleaning resorting to nebulized water with soft brushing, the progressive shift upwards represents the increments in the likelihood of damage as a direct consequence of the higher vulnerability ratings and the attribution of a synergetic effect (from the brushing) for the two most decayed surfaces.

The triangles correspond to the surfaces with different significance levels illustrated in Figure 5.3 when cleaned, for instance, with $Na_2EDTA$ poultices in a 1.5% solution (A=1; B=5; C=1.5x2=3). They fall along the same row because a similar damage likelihood was computed for all of them, matching their very similar condition. In the Cleaning Risk Matrix it is possible to have a clearer idea on how the risk progresses and to conclude that the same method may be viable for the less valuable areas but it may be deemed unviable for the more significant ones.

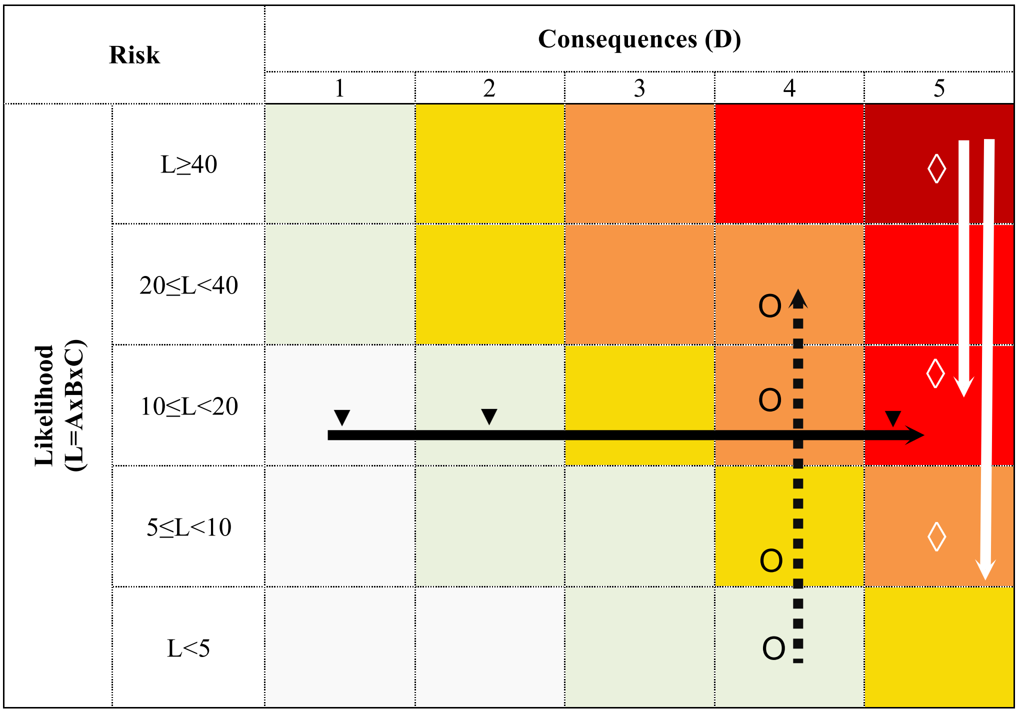


**Figure 6.2:** Progression of risk levels across the Cleaning Risk Matrix. Theoretical examples, as per the captions in the referenced figures: O – Cleaning the surfaces in Fig.5.2 with nebulized water w/ brushing: risk increases with vulnerability; ▼– Cleaning the surfaces in Fig.5.3 with Na2EDTA poultices (L=15): risk increases with significance; ◊ – Cleaning the surfaces in Fig.6.1 with nebulized water w/ brushing (L≥40), ammonium carbonate poultices (L≈19) and laser applied below ablation and discolouration thresholds (L≈5): risk is lower for gradually less aggressive methods.

Finally, the diamonds represent the example depicted in Figure 6.1 to illustrate how to act when the user considers the risk unacceptable. The sequence of reasoning goes through the hypothesis of a milder method (poulticing with ammonium carbonate), to the perception of a still excessively high risk and the considering of the possibly least harmful laser method, if applied below ablation and discolouration thresholds. It also illustrates how a high degree of significance and the very high vulnerability of the surfaces yield very concerning risk results even for methods that are generally regarded as relatively mild.

### *6.2. Risk criteria*

As seen, and strictly speaking, the risk index method is a risk analysis method; for the actual decision making, an evaluation of the risk levels obtained following the analysis is necessary. In turn, for evaluating risk, criteria should be defined from the outset of the analysis against which the obtained risk level will be pondered. These criteria may define risk level thresholds of 'acceptable' or 'unacceptable', and may further include a threshold for 'tolerable' risk. An illustration of the latter division is the so-called ALARP (As Low As Reasonably Practicable) principle, depicted in Figure 6.3, based on the concept of practicability: "The concept of practicability in ALARP contains within it the ideas of practicality (*Can something be done?*) as well as the costs and benefits of action or inaction (*Is it worth doing something in the circumstances?*)" (AS/NZS 2004b: 65, italics in the original text). This principle was introduced by the British Health and Safety Executive (HSE) in the nowadays called 'TOR [Tolerability of Risk] Document' and became the most widely used reference when discussing the acceptability of risk (IPSN 2000). The HSE defined tolerability as follows:

> Tolerability does not mean acceptability. It refers to a willingness to live with a risk so as to secure certain benefits and in the confidence that it is being properly controlled. To tolerate a risk means that we do not regard it as negligible or something we might ignore,

> but rather as something we need to keep under review and reduce still further if and as we can. To fit in the tolerability region, a risk must be kept as low as reasonably practicable (ALARP principle). It is also clearly stated that a risk is regarded as intolerable when it cannot be justified in any ordinary circumstances. Finally, the broadly acceptable region is set by the point at which the risk becomes comparable to those that people regard as insignificant or trivial. (HSE TOR Document, quoted in IPSN 2000: 12)

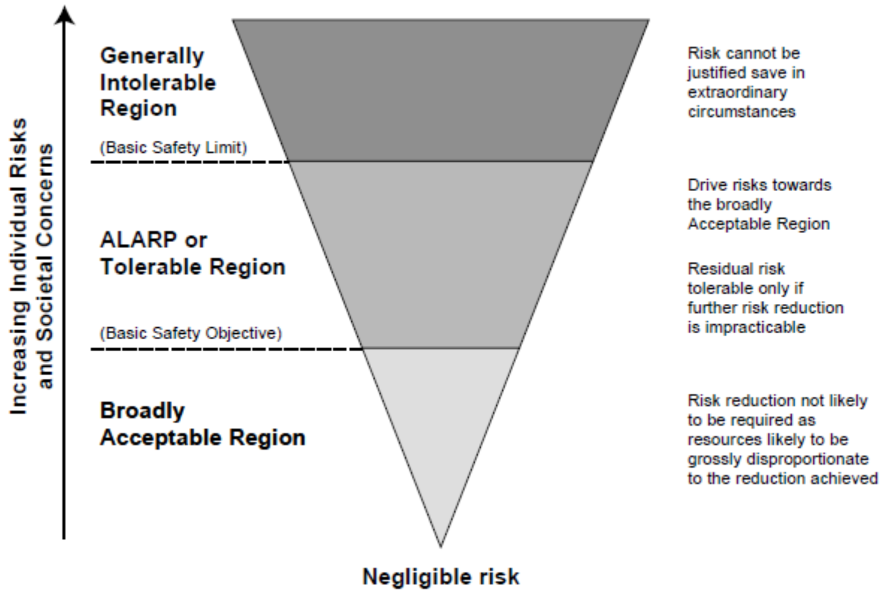


**Figure 6.3:** Risk criteria as defined by the HSE. (AS/NZS 2004b: 66)

The establishment of risk criteria depends on the perception of risk of the involved actors. Risks to built heritage objects will generally be classified as societal risks, given their scale of incidence, which corresponds to the size of the stakeholder group. The risk perceived by social groups is "influenced not only by the nature of the risk, but also by the degree of available information and ethical, cultural, social, political, psychological and economical aspects" (Caldeira 2005: 14).

In this context, it may be useful to distinguish 'technical acceptability', which is a risk level defined by technicians, scientists or other decision makers, from 'public acceptability' (sometimes named 'acceptance'), which reflects the sum of individual judgments on the situation at hand (IPSN 2000). The two levels do not necessarily match; in fact, the increasingly wider use of the 'tolerable' level is an attempt to cope with those discrepancies:

> The term risk acceptability carries the inference that society knowingly and willingly accepts risks as the reasonable price for a beneficial technology or activity. But most risks are imposed or imperfectly informed risk bearers who often lack the freedom to accept or reject the risk….Hence the term risk tolerability more adequately describes the nature of the problem. (Kasperson, quoted in IPSN 2000: 8)

The establishment of risk criteria bears value judgments that should be adequately handled by taking into account the needs and views of the concerned stakeholders; risk communication and expert consultation are generally advised, particularly when data on societal risk aversion is missing, as is the case for losses in cultural heritage assets. Ultimately, the definition of criteria should be decided case-by-case:

> [H]istory suggests that acceptable risk will ultimately be defined on a case-by-case basis. Key decision factors such as the size of the exposed population, the resource costs of meeting risk targets, and the scientific quality of risk assessments vary enormously from one decision context to another. Administrative discretion is necessary to weight these factors on a case-by-case basis. No magic risk number can substitute for informed and thoughtful consideration by accountable officials who work with the public to make balanced decisions. (Graham, quoted in IPSN 2000: 23)

Depicting the risk levels in a risk matrix may assist in the risk evaluation phase in two ways:

(i) by allowing comparisons between different strategies, as illustrated above: in the present case, attention is drawn to the fact that two of the factors under analysis are somewhat fixed: the vulnerability of the surface and the significance of the object. Since the damage consequences are solely appraised in terms of the impact on significance, the different cleaning options for a given surface will necessarily be juxtaposed in terms of their likelihood to inflict damage, thus facilitating an immediate comparison of risk levels;

(ii) by using risk levels as risk evaluation criteria (AS/NZS 2004b), e.g. defining 'High', 'Very high' and 'Extreme' risks as unacceptable; 'Medium' risks as tolerable; 'Low' and 'Very low' risks as acceptable.

The applicability of the risk matrix is thus twofold: not only it allows for the comparison of different cleaning methods, it will also let the planner establish thresholds below which the cleaning methods will be deemed 'incompatible' and their use precluded.

### *6.3. Some remarks*

Synthesizing the results of the proposed risk assessment allowed proposing a procedure for the assessment of cleaning compatibility (Revez & Delgado Rodrigues 2016); schematically, this procedure is described by the flowchart in Figure 6.4. It is suggested that assessing the compatibility of cleaning a heritage object amounts to judging the risks that the cleaning action presents to the significance of that object. These risks depend on (1) the susceptibility of the (target) surface to cleaning; (2) the aggressiveness of the cleaning methods; (3) the interactions between the methods and the surface; (4) the impact on the significance of the object and (5) the quality components involved in the intervention.

Once the risk analysis is performed, risks should be evaluated using the risk matrix, and, if deemed tolerable or acceptable, the cleaning action is considered compatible; incompatible cleaning methods will yield untolerable risks, and alternatives will have to be sought, either by choosing milder cleaning methods; by enhancing quality-component planning; or by changing the target surface to a more conservative level.

If more than one method proves compatible, then it is for the planner to decide how to tackle the involved risk (given that there are no risk-free actions), which will plausibly amount to choosing the risk-minimizing method depending on the estimated costs and benefits of each alternative.

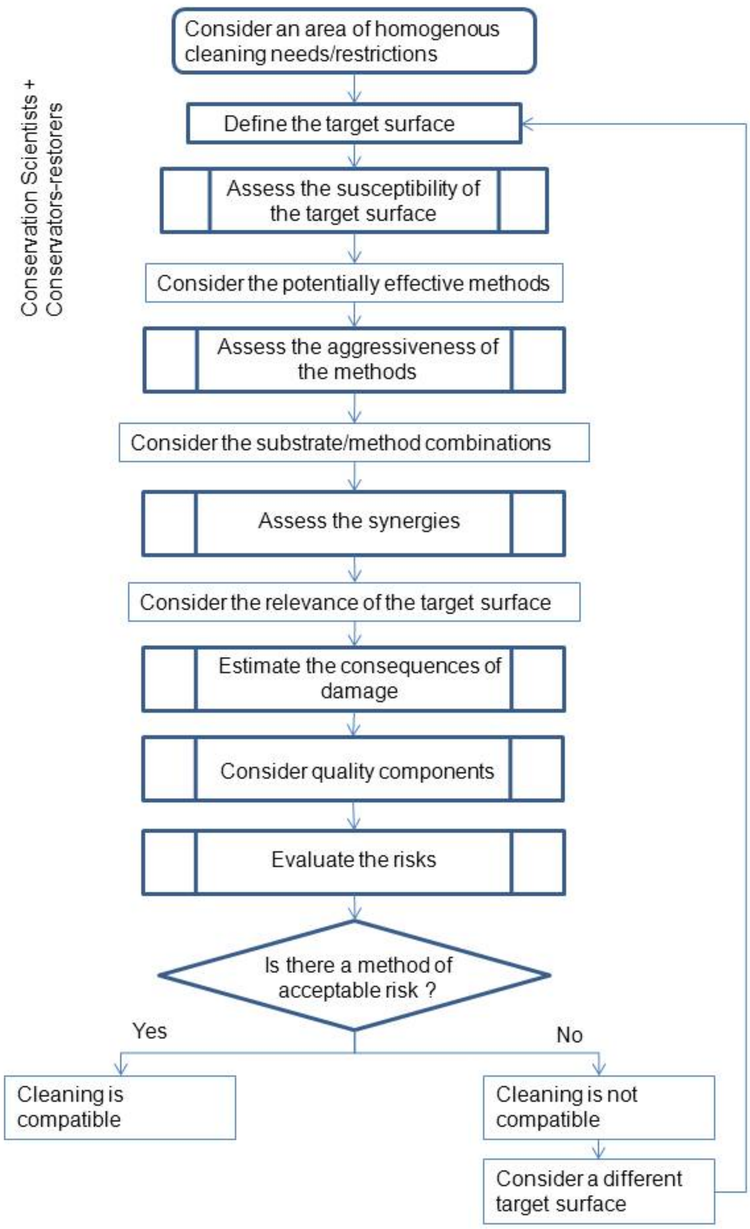


**Figure 6.4:** Flowchart description of the (in)compatibility risk assessment of built heritage cleaning.

# 7. Results validation

## 7.1. *Delphi exercise outline*

The incompatibility risk assessment procedure for built heritage cleaning described in the previous chapter, and as reported by Revez & Delgado Rodrigues (2016), was subjected to expert evaluation using the Delphi Method.
A total of fifteen to twenty experts seems to suit most studies using Delphi (Hsu & Sandford 2007). For the evaluation of this procedure, a panel of fifteen experts, including nine conservation scientists, three conservator-restorers and three governmental heritage overseers, gave their opinions throughout three Delphi rounds, sent and received via email.
Consensus was defined as agreement by 80%, i.e. twelve, of the panellists.
A summary report of the Delphi exercise, including the questionnaires and accompanying documents sent to the panellists in all three rounds, is available in Appendix D.

## 7.2. *Delphi exercise outcomes*

### 7.2.1. First round

The First round of the Delphi method application included the first version of the procedure and an open-question survey. Panellists were invited to read the procedure, and then give their opinions in a questionnaire sectioned as follows: Vulnerability – Aggressiveness – Synergies – Impact on Significance – General appreciation of factors – Cleaning Risk Matrix – Planning factors (later Quality components). For each factor, a set of questions essentially inquired about the pertinence of the chosen classification parameters and of the ratings these were ascribed; in the ‘General appreciation of factors’ set, the panellists were asked about the overall pertinence of the chosen factors.

The panellist answers were analysed and revealed that the four ‘hard’ factors used to assess incompatibility risks (vulnerability; aggressiveness; synergies; and impact on significance) were approved by consensus; the panellists furthermore agreed on the relevancy of the quality components. The zoning of the Cleaning Risk Matrix gathered consensus pending testing with real case-studies. Expert comments were noted and the procedure was edited to meet some of the issues raised; also, some of the offered suggestions were followed and added to the procedure, while others were not. A report introducing the experts’opinions and ensuing edits and additions, as well as the reasons for not following some of the suggested ideas, was prepared as a working document to be sent to the panellists in the Second round. The table below displays some examples of the outcomes obtained in this first round, as reported to the panellists in this working document, which may be consulted in Appendix D (Second round document).

**Table 7.1:** Illustrative examples of the First round outcomes of the Delphi exercise.

| Factor/section | Delphi result examples (quotations from the Second round working document) |
|---|---|
| Vulnerability | *Regarding the adding of substrates, many suggestions were made, although only one panellist suggested a rating scheme for the proposed addition. Most suggested substrates were added to the table. Adobe and alabasters were suggested, but considered to be too specific and thus slightly too distant from the context of this procedure. Following the concept behind it, we aimed for a table with common substrates that would be indicative, and not prescriptive; we hope that now the substrates are enough for a planner to find a reference he/she can use or adapt.* |
| Aggressiveness | *In accordance with panellist suggestions, the following methods were added to the table: steam jet; chelating agents; ultrasounds; rotary tools; and examples of hand tools. Dry ice and bacterial and enzymatic cleaners were inserted as notes in the 'Guidelines' section of the table.*<br>*A suggestion for introducing a 'Biological methods' class was not followed and a 'Guideline' was added instead, because the proposed class would just contain bacterial cleaners (since enzymes are chemical agents, i.e. their action is chemical, even if their origin is biological); this seemed to make the table overly complex and we believe that they can be justly considered as chemical cleaners, hence the note in the 'Guidelines'.* |
| Synergies | *One panellist, and then three more panellists when answering section 5 ('General appreciation of the chosen factors'), believes that the increment assessment should range between 1 (one) and 3 (three), since "1 might be considered as 'good' and 2 as 'bad'".*<br>*Answer: This change was not implemented because parameters included under synergies were meant to function as "risk amplifiers", and thus the chosen range; 3 would amplify the risk threefold, which was considered excessive.* |
| Impact on Significance | *Regarding specifically the "listed/unlisted" grouping, only four panellists agree with this grouping scheme unreservedly; four other panellists do not think that the listing of an object is necessarily a match to its significance, and expressed concerns about the implications for significant yet unlisted objects; however, these panellists acknowledged the difficulties in coming up with a different assessment grouping and/or recognized the pragmatism of such a division, and therefore agreed with the scheme proposed.*<br>*Three panellists, however, disagree with assessing the significance of an object based on its listing status and two of them proposed the following changes: (1) the plain removal of the listed/unlisted division, with the ratings varying between 1 to 3 for low relevance surfaces and 3 to 5 for high relevance surfaces; or (2) the removal of the listed/unlisted division plus making the ratings depend on significance assessments made prior to the intervention.*<br>*Answer: While acknowledging the possible flaws of this grouping, it is considered that some objects are more culturally significant than others, and this should be expressed in this ranking, since consequences of losses on these objects will be more serious than on comparatively less significant ones. The listed/unlisted status of the object does not depend on the planner, something which was considered desirable to make the assessment slightly less subjective. Nevertheless, the words "or equivalent" were added to the table, for the cases where the objects are not yet listed but are very significant. Making the ratings depend on a thorough significance assessment would of course be the best scenario, but unfortunately significance assessments are still not a standard procedure, at least in Portugal, and to require such an assessment could hamper the use of the procedure altogether, since evaluating consequences is a crucial part of risk assessment.* |
| General appreciation of factors | *One panellist finds that "The risk for the operator and for the environment should also be considered. A rating scale could be: 3 (dangerous), 2 (requiring very strict conditions for the protection of the operator or the environment), 1 (safe for the operator or the environment)."*<br>*Answer: these risks are real possibilities, but will happen only when the safeguarding measures inherent to the concerned method are not taken in due consideration. To a certain extent, this aspect may be taken in a way similar to the one proposed to deal with effectiveness. For the intents and purposes of the present assessment, it is assumed that* |

| | |
|---|---|
| | *protection of the operators and potential environment impacts are eliminated or minimized.* |
| Cleaning Risk Matrix | *One panellist commented that the attributing a classification of "Medium" to the L<5 class seemed "excessively prudent", and questioned whether cleaning a high- or very high-significance surface should always be considered as a 'Medium' risk action. The panellist further commented that in general the risk grades seemed to be overly conservative, although the panellist agrees with this overrating of the risk.*<br>*Answer: for the highest significance surfaces (D = 5), we found that the seriousness of damage consequences required a "Medium" risk classification at least, whatever the method under analysis. Nevertheless, after reanalysing our case studies, we realised that a certain excess of prudence might have been used in the first matrix, and so a few changes were made.* |
| Quality components | *One panellist suggested that "mapping of the conservation state" should be added under 'Preparatory'. This suggestion was followed.* |

As a result of the first Delphi round, all assessment tables were edited following panellist comment. In general, additional parameters were added to the assessment tables and/or some of the ratings were reviewed; table guidelines were also edited and the texts introducing each factor needed clarification or further explaining.

### 7.2.2. Second round

Two documents were sent for the second Delphi round: (1) a full transcript of all the panellist answers to the first round[39], with minor edits intended to make the different contributions anonymous; and (2) the questionnaire proper (see Appendix D – Second round).
The questionnaire was sectioned similarly to the one sent in the previous round (Vulnerability – Aggressiveness – Synergies – Impact on Significance – General appreciation of factors – Cleaning Risk Matrix – Quality components). Each chapter started by presenting the new (edited) version of the corresponding procedure section (except of course the 'General appreciation of the factors' chapter, which had no corresponding procedure section), with the edits signalled for easy identification. These (edited) procedure sections were each followed by the reporting of the first round results for that specific section, contextualizing the introduced edits; panellist suggestions that were not followed were additionally reported, along with a justification. Throughout this reporting, yes/no questions assessed the opinions of the panellists regarding both the changes introduced to the procedure following expert comments and the reasons for not following some of the suggestions.
In the end, three summary examples of cleaning interventions recently performed upon Portuguese heritage, which benefited from scientific consultation and were generally regarded as successful, were added to the Delphi questionnaire. These examples illustrated the application of the procedure to the Delphi panellists, who were also invited to apply the procedure to interventions they had personal experience on.

After the Second round, the parameters used to assess each of the factors (including the 'soft' factor, Quality components) and the Cleaning Risk Matrix zoning were generally approved by consensus. Consensus was achieved in all but one of the sixty one questions posed to the panellists. Nevertheless, given that the issues raised in this question by some of the objecting panellists seemed to have been resolved in the previous round, a consensus was assigned to the question, subject to expert judgement in the third round.

For example, for the Vulnerability factor, the fragment transcribed in the table above was followed by the question "Do you agree with all of the added substrates?". This question was answered yes or no, and some of the panellists made additional comments; the Second round results report, sent to the panellists in the Third round (see Appendix D – Third round), included

[39] Given its dimension and the fact that its results are reported in the other second round document, this full transcript was not included in this dissertation.

an account of 'Yes' and 'No' answers, as well as answers to the panellists'comments, as displayed below.

| **5. Do you agree with all of the added substrates?**<br>*Yes=14*<br>*No=1*<br>**Consensus reached** |
|---|
| ***Remarks*** |
| ***Panellist 7***<br>[Yes] *I suggest adding 'ultramafic, gabbro'. I believe that serpentinites are missing - there is a lot of serpentinite in Europe* |
| ***Panellist 13***<br>[Yes] *But you can´t talk any more of stone heritage conservation.* |
| ***Panellist 15***<br>[No] *Adding mortars and renders is not helpful - if you introduce mortars then you will need to differentiate between different types (lime, gypsum, natural cement) & sub-types (e.g. for lime, CL90, NHLs, lime/pozzolanic mixes). This is a separate thesis, and not a helpful comparison for stone cleaning.*<br>*Adding brick & concrete is similarly not helpful, and does not help with your assessment procedure.* |

**Answers to Panellists**

In view of the comment from Panellist 7, "gabbro and similar rocks" was added to the 'Basalts' table entry.

We would also like to draw attention to the fact that the procedure is to be used for Built Heritage Cleaning, and therefore should try and encompass other elements that may be present, such as tiles, brick or concrete – and mortars and renders.

Regarding the comment from Panellist 15, we agree that mortars are extremely complex and variable materials, but not necessarily more complex than each of the groups of lithotypes listed in the Vulnerability table. We believe that, in terms of vulnerability to cleaning, they may (and should) be assessed and rated.

The question that did not achieve an immediate consensus integrated the 'Impact on significance' factor:

| ***41. Do you agree with the explanations offered in support of the "listed/unlisted or equivalent" criterion?***<br>*Yes=11*<br>*No=3*<br>*N/A=1*<br>**Assigned consensus** |
|---|
| ***Comments*** |
| ***Panellist 3***<br>*Why the significance – listed – non listed issue is introduced into the paper at all? Isn't it much better to not interfere into the problems of classifying monuments? This paper should only deal with the scientific problems of cleaning and the assessment of the respective methods to various surfaces.* |
| ***Panellist 11***<br>*The aspect "significance" when dealing with cleaning has to be broadly applied, including the environment where the object is located.* |
| ***Panellist 13***<br>*In* [my country] *the listing of an object is often a political decision, and has nothing to do with the significance of it.* |

**Answers to Panellists**

Regarding the objection of Panellist 3, we would like to say that we do not wish to interfere with the classification of monuments – far from it: we merely use it as a widely accepted reference of what we think must be considered when using the Procedure. This way, the assessment is not entirely dependent on user judgement.

Furthermore, we consider that the remark of Panellist 11 does not invalidate the criterion: it reads like a suggestion for a better (more detailed) 'Impact on significance' assessment, and not as a need for an alternative. Expecting to resolve this 'No', we have added one more Guideline to Factor D.

As for Panellist 13, the words "or equivalent" were added to the table, precisely to solve this objection. Without an alternative from the Panellist or an explanation on why this alternative doesn't solve the question, we have to consider this issue as solved.

The answers imply a formal "No consensus", since consensus required twelve instead of eleven 'Yes' answers. This would require a Third Round, but, given the Panellist comments, we face a practical dilemma:

1) Objections from Panellists 3 and 13 concern the inclusion of the 'listed/unlisted or equivalent' criterion; these two objections, considered alone, would configure a Panel consensus;

2) The objection of Panellist 11 concerns the need to include environment on the significance assessment, which we take as an added guideline that does not contradict the proposed scheme;

3) Apparently no more than two 'No' were given to a same argument.

Considering the eleven 'Yes' answers already given and the solution given to the objection of Panellist 11, we think that a Third Round is not justified, even more so considering that no better alternative to harmonize the eleven 'Yes' and the three objections could be delineated.

Based on these judgments, we decided to assign a consensus to the question.

### 7.2.3. Third round

After the Second round, the expert comments were noted and the procedure was further edited and resent to the panellists for approval (See Appendix D – Third Round). These were very minute edits and, therefore, the final round consisted of a general question to the experts on whether they agreed with the (signalled) edits or not, also drawing attention to the 'assigned consensus'. This round yielded no disagreement.

The entire process was highly participated, with useful and accurate contributions, which greatly helped in building a more supported methodology. The final version of the procedure, reported in (Revez & Delgado Rodrigues 2016), corresponds to a (slightly) further edited version, following late panellist contributions and the suggestions of the referees proposed by the journal to which this procedure was submitted.

# 8. Conclusions

*We shape our buildings and afterwards our buildings shape us.*
Winston Churchill, Address to the Commons Chamber (October 1943)

### Synopsis

This dissertation presented the research undertaken with the purpose of operationalizing the heritage conservation principle of compatibility to support decision making. The process entailed analysing conservation goals and accepted principles, as well as defining ‘compatibility’ for use in conservation decision-making processes; seeing as assessing compatibility involves a judgement on the acceptability (or tolerability) of potential damage being inflicted upon the (conservation) object, it was argued that a risk assessment would be the most adequate tool for devising a compatibility-based procedure. Such a procedure was developed for supporting the planning of built heritage cleaning interventions: a literature review on the topic allowed the application of a risk index analysis, which, in turn, permitted to build a semi-quantitative rating system of factors affecting the likelihood and the consequences of the occurrence of (in)compatibility risks; the procedure furthermore proposes a risk matrix to guide planners in the assessment of their specific risks. The validity of the developed tools was established by a Delphi panel.

### Main Results

‘Compatibility’, as defined by the CEN Standard EN 15898:2011 and extended to include ‘methods/actions’, appears to be a functional guiding concept for the planning of conservation interventions: it allows the integration of significance, authenticity and integrity into the analysis; it is a widely held conservation principle; and it is applicable at different intervention levels, from product choice to the intervention as a whole. On the other hand, the operationalization of the concept into a planning tool via a risk assessment methodology enabled the obtaining of a procedure that met the approval of a purposely convened panel of conservation experts. This seems to indicate that risk assessment may assist in the implementing of ‘compatibility’ as an operative concept for conservation decision making.
Similarly to what was proposed by Delgado Rodrigues & Grossi (2007), this (in)compatibility risk assessment procedure for built heritage cleaning deconstructs a complex concept into simpler parameters in different categories. Albeit its development tools were different, the procedure was aimed at integrating the Prodomea Eight-Step planning model and it thus may be applied in the same planning contexts, complementing the (In)compatibility Assessment tables.

Often, the planning of conservation actions to be carried out upon cultural heritage sites does not have the necessary resources for scientific consultation, even in the case of high-budget interventions (Revez et al. 2012). This means that decision making at the planning stage will be highly contingent of the specific training, experience and subjective views of the planner, who may not be aware of all the options and constraints facing them. In this context, the proposed procedure may help in guiding the planning process by framing subjectivity and highlighting aspects that cannot be oversighted when considering a cleaning action on a heritage object. Moreover, an effort was made for the procedure to list all the factors deemed relevant for fulfilling the goals of an ethical conservation intervention in a simple manner, thus allowing its use by non-specialists in masonry materials; the parameters are relatively easy to obtain: using the tables, a site manager should be able to identify and rate all four 'hard factors' and, from there, be able to discuss alternative solutions and plan for quality components that keep the risk at a tolerable minimum.

In presenting a comprehensive sequence of relevant parameters projected for the framing of a cleaning intervention, the procedure may also be of interest in the implementing and controlling phases, where it may be used as a checklist of the factors influencing the output of any given cleaning action. Checklists can bring about outstanding differences to operational standards, namely by reminding professionals of details that may go overlooked; and by establishing minimum required steps that absolutely must be verified (Gawande 2007).
Lastly, the procedure may also be used to evaluate past interventions: coupled with post-cleaning monitoring information, it may serve as a knowledge tool and assist in the building of a more systematic understanding of the risks involved in cleaning. Casuistry, i.e. reasoning based on making comparisons and drawing analogies, has been argued to stand at the very core of (ethical) problem solving in conservation (van de Vall 1999) and both good and not so good practices (Brajer 2009) should be reflected upon to build the necessary knowledge to, borrowing from Beckett's *Worstward Ho*, fail better.

Depending on the complexity of the case under consideration, the available information and programmed outcome, the procedure can be applied by fairly informed users or experts in conservation sciences; to obtain elements ranging from simple general overviews to detailed justified operational decisions. It should nevertheless be underlined that applying this procedure for the assessment of incompatibility risks of built heritage cleaning implies:

- that the user(s) have an at least basic knowledge of heritage masonry structures;
- that the context of application is duly established, and that the need for cleaning was analysed and adequately justified;
- that the procedure is applied in its entirety, i.e., that all the risk factors are analysed.

It should be stressed that this procedure aims at reducing subjectivity, but cannot altogether eliminate it. A certain degree of subjectivity will always be present in the assessments, and this procedure must be taken as a guide, and not as a prescription.

### Contribution to the discipline of heritage conservation

The research reported herein posits that an incompatibility risk-based approach to heritage conservation actions may adequately support the intervention planning in a way that agrees with the current priority given to the sustaining of heritage significance.
The application of risk assessment to the conservation of cultural assets is not novel, having been proposed and applied in various scopes, ranging from collection management (Ashley-Smith 1999; Waller 1994, 1996) to emergency preparedness (AA.VV. 2007, 2012, 2013; Stovel 1998; UNESCO 2010); from the development of methodologies for prioritizing interventions (Baldi et al. 1995; Ibáñez et al. 2016) to studies more focused on environmental impacts upon heritage (Galán & Aparicio 2013; Ortiz et al. 2014) and, even, to the project management of interventions (Thaheem 2014).
It is, however, the first time that a conservation ethical guideline – compatibility – is proposed as the operative concept for risk analysis. The use of the compatibility principle subordinated to

the significance of the object is thought to provide a clearer conceptual framework for the risk assessment, thus helping the planner in keeping their priorities on sight throughout the whole planning, execution and control processes.
Yet, it is the use of compatibility as operative concept that arguably imparts a limitation to the proposed model: it deals solely with negative risks, i.e., it is not able to provide a framework for the analysis of positive impacts, and it is therefore unable to encompass the potential benefits of conservation or, more specifically to the context presented here, of heritage cleaning. In other words, while incompatibilities may be more or less easily ranked, it is not correspondingly straightforward to define levels for the ranking of compatibilities. On the other hand, the (negative or positive) risks of *not* undertaking the intervention are not tackled by this procedure either.

Still, the presented approach is thought to constitute a helpful tool for supporting decisions in built heritage cleaning, and it is hoped that it will (1) encourage researchers to provide clearer criteria for their choice of methods, including acceptability and/or tolerability thresholds; and (2) aid planners and practitioners in acknowledging the stakes of conservation interventions more transparently and, thus, to report conservation decisions more comprehensively. In the Portuguese heritage conservation reality, which is often found lacking in terms of frameworks or guidelines for good practice, it is considered that this procedure may represent a valuable support instrument. The presented literature survey and discussion on heritage values is also aimed at providing potential users with tools for supporting significance analysis, which is arguably the most foreign concept when dealing with planning actions at a material level.

### Further directions

Firstly, the proposed assessment procedure would certainly benefit from its application to real cases, in order to better appraise its robustness. Case-study analysis, which allows the investigation of a "contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident" (Yin 2003: 13) is suggested as research tool, since conservation interventions are inherently context dependent. The application of the procedure to past heritage cleaning interventions could furthermore assist in verifying the cleaning risk matrix levels and, eventually, in supporting the application of these levels for the definition of risk criteria.
Another aspect that could perhaps be improved within the this procedure is its treatment of the 'soft' factor, i.e., the analysis of the human component. Human Reliability Analysis (HRA) is a risk assessment tool for the establishing of "the impact of humans on system performance and can be used to evaluate human error influences on the system" (IEC 2009: 61). HRA corresponds to a structured sequence of analytical steps that may be performed qualitatively; it uses inputs such as task definition and knowledge of former errors and their potential for (re)occurrence, and returns "a list of errors that may occur and methods by which they can be reduced; […] error modes, error types causes and consequences; qualitative or quantitative assessment of the risk posed by the errors" (IEC 2009: 62-63) It requires, however, a strong expertise on the occurrence of (human) errors and detailed enough information on the impact of the human factor.

It would also seem that there might be gains in, analogously to what was debated here for the cleaning of built heritage, applying a risk assessment to the conservation actions foreseen in Delgado Rodrigues & Grossi's (In)compatibility Assessment (2007), e.g. to the choice of consolidants, water repellents and/or repair mortars; or, even, as an integrating tool for the environmental, operational and/or socio-cultural constraints. The authors of the (In)compatibility Assessment explicitly encouraged debate and discussion of procedure applications, eventually allowing for establishing the indicators more definitely; for tuning their proposed ratings more finely; and for ascribing criticality where necessary. This debate has started already (Silva et al. 2015) but it still requires further experimental lab and field research, and it is suggested that this research could benefit from the risk framework proposed here as

integrating background.
Eventually, the incompatibility risk assessment reasoning could be applied to support treatment decisions involving different typologies of heritage objects; beginning, for example, with developments for the adaptation of the procedure to (stone) sculptures or archaeological objects, as well as to objects wih polychromy.

Still another issue that undoubtedly merits further in-depth analysis regards the consequence assessment of conservation interventions. This analysis would permit to broaden the scope of risk management within the discipline of conservation and would likely bring an added awareness to to the risks involved by planning, execution and control actions. The parameters suggested here for measuring these consequences, which stem from proposals, within the conservation discipline, of ascribing semi-quantitative levels of significance to heritage objects and elements within these, need further discussion and refining. Analogously to what it has been achieved in the significance assessment of environmental assets (Sujarwo & Caneva 2016), indicators need to be developed for a more precise and less subjective evaluation of the stakes of conservation interventions; ethnology tools could perhaps assist in this development.

# Glossary

Throughout this dissertation, the definitions alphabetically listed below apply.

| Term | Definition |
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| Ageing | “Natural *alteration* over time” (CEN 2011: 9)<br>N.B.: “Ageing can also be simulated or artificially produced.” (CEN 2011: 9) |
| Alteration | “Change in *condition*, beneficial or not, intentional or not.” (CEN 2011: 8) |
| Authenticity | “Extent to which the identity of an *object* matches the one ascribed to it.” (CEN 2011: 8)<br>N.B.1: “The concept of authenticity should not be confused with the concept of originality” (CEN 2011: 8)<br>N.B.2: “Depending on the nature of the *cultural heritage*, its cultural *context*, and its evolution through time, *authenticity* judgements may be linked to the worth of a great variety of sources of information. Aspects of the sources may include form and design, materials and substance, use and function, traditions and techniques, location and setting, and spirit and feeling, and other internal and external factors. The use of these sources permits elaboration of the specific artistic, historic, social, and scientific dimensions of the *cultural heritage* being examined.” (UNESCO & ICOMOS 1994: art.13) |
| Cleaning | *Remedial conservation procedure* consisting on the “removal of unwanted material from an *object*.” (CEN 2011: 12)<br>N.B.: “The criteria for something being "unwanted" always have to be stated, e.g. potentially damaging, obscuring detail, un-aesthetic, etc.” (CEN 2011: 12) |
| Compatibility | Extent to which a material, method or action may be used on an *object* without putting its present or future *significance* at *risk*. (Adapted from CEN (2011: 10)) |
| Condition | “Physical state of an *object* at a particular time.” (CEN 2011: 8)<br>N.B.: “Assessment of the state of an *object* depends on the *context* and thus on the reason why the assessment is being made.” (CEN 2011: 8) |
| Condition Report | “Record of *condition* for a specific purpose, dated and authored”. (CEN 2011: 14)<br>N.B.: A *condition report* “normally results from a condition survey” (CEN 2011: 14) or assessment inspection. |
| Consequence | “Outcome or impact of an *event*.” (AS/NZS 2004a: 2)<br>“[N.B.]1: There can be more than one consequence from one event.<br>[N.B.]2: Consequences can range from positive to negative.<br>[N.B.]3: Consequences can be expressed qualitatively or quantitatively.<br>[N.B.]4: Consequences are considered in relation to the achievement of objectives” (AS/NZS 2004a: 2) |
| Conservation | “All the processes of looking after a *place* so as to retain its *cultural significance*.” (ICOMOS Australia 2013b: art.1.4) |

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| | "The process of managing change to a *significant place* in its *setting* in ways that will best sustain its heritage *values*, while recognizing opportunities to reveal or reinforce those *values* for present and future generations." (English Heritage 2008: 71)<br>N.B.1: "All conservation actions are based on documentary and/or material evidence." (CEN 2011: 10)<br>N.B.2: "Conservation includes *preventive conservation*, *remedial conservation* and *restoration*" (CEN 2011: 10) |
| Conservation Planning | "Management tool for the development and coordination of conservation measures and actions." (CEN 2011: 14) |
| Conservation Scientist | "A professional scientist whose primary focus is the application of specialized knowledge and skills to support the activities of *conservation* in accordance with a [*conservation*] ethical code" (AIC 2014) |
| Conservator-restorer | "The *Conservator-Restorer* is a professional who has the training, knowledge, skills, experience and understanding to act with the aim of preserving *cultural heritage* for the future. […] The Conservator-Restorer contributes to the perception, appreciation and understanding of *cultural heritage* in respect of its environmental *context* and its *significance* and physical properties. The Conservator-Restorer undertakes responsibility for, and carries out strategic planning; *diagnostic* examination; the drawing up of *conservation plans* and *treatment* proposals; *preventive conservation*; *conservation-restoration treatments* and *documentation* of observations and any *interventions*." (E.C.C.O. 2002: sec. I) |
| Consolidation | *Remedial conservation procedure* consisting on the "improvement of internal cohesion or mechanical stability, usually involving the addition of material." (CEN 2011: 12) |
| Context | "Past, present and future circumstances affecting *significance*." (CEN 2011: 8)<br>N.B.: "Context refers to the circumstances, tangible and intangible, in which an object is created, built, used, worshipped, found, excavated, kept, presented, etc." (CEN 2011: 8).<br>In other words, context "refers to physical, geographical surroundings; to historical patterns and narratives; and to the social processes with discernible impact on *heritage* and its *conservation*. These include the cultural, social, economic, and other conditions contributing to *significance*, as well as the management setting and physical surroundings of the *site*." (Mason 2002: 14) |
| Cultural heritage/ Heritage | Conceptually, it is "ultimately a cultural practice, involved in the construction and regulation of a range of values and understandings" (Smith 2006: 11) corresponding therefore to a "Constructed history that is intentionally biased toward a particular group or issue." (Matero 2003: 15)<br>In terms of presentation, heritage may be described as "*Tangible* and *intangible* entities of *significance* to present and future generations" (CEN 2011: 7), or as "Assets which people identify and value as a reflection and expression of their evolving knowledge, beliefs and traditions, and of their understanding of the beliefs and traditions of others." (English Heritage 2008: 71)<br>N.B.1: Because selecting an entity of significance is a cultural behaviour, the terms *Cultural heritage* and *Heritage* are considered interchangeable throughout this dissertation and used accordingly. *Natural heritage*, which may be considered as a subtype of *Heritage* encompassing solely naturally-occurring assets or entities, is referred to specifically when necessary. |
| Damage/Decay/ Deterioration | *Alteration* that reduces *significance*. (Adapted from (CEN 2011: 9))<br>N.B.1: *Damage* generally refers to sudden (*significance*-reducing) *alterations*, whereas *decay* and *deterioration* are preferred for gradually occurring (*significance*-reducing) *alterations*.<br>N.B.2: These terms may also be used to describe the process.<br>N.B.3: References to specific decay patterns follow the definitions in the "ICOMOS-ISCS Illustrated Glossary on Stone Deterioration Patterns" (ICOMOS-ISCS 2008). |
| Defect | "Imperfection of an *object* due to its conception, its production or its construction process or to the nature of the materials employed." (CEN 2011: 9) |

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| Designation/listing | “The recognition of particular heritage *value(s)* of a *significant place* by giving it formal status under law or policy intended to sustain those *values*.” (English Heritage 2008: 71). See also *legal protection*. |
| Diagnosis | “Process of identifying the present condition of an object and determining the nature and causes of any change, as well as the conclusions drawn.” (CEN 2011: 15)<br>N.B.: “Diagnosis is based on observation, investigation, historical analysis, etc.” (CEN 2011: 15) |
| Documentation | “Recorded information created, collected, held and maintained for the purpose of present and future conservation and reference”, e.g. “X-radiographs, drawings, photographs, written reports, computer files, photogrammetry, laser-scanning”. (CEN 2011: 15)<br>N.B.: This term may also be used to describe the process. |
| Durability (of a material or product) | “Ability to resist the effects of wear and tear in performance situations” (CEN 2011: 10) |
| Emergency preparedness | “Measures and actions taken in advance to mitigate the effects of possible destructive events”, including “drawing up a disaster response plan”. (CEN 2011: 12) |
| Environment/Settin g | “Surroundings of an *object*, some aspects of which may affect its *condition*.” (CEN 2011: 8)<br>N.B.1: “Such aspects could be of human, physical, chemical, biological or climatic origin.” (CEN 2011: 8)<br>N.B.2: The term *Historic Environment* may be used for “all aspects of the environment resulting from the interaction between people and places through time, including all surviving physical remains of past human activity, whether visible or buried, and deliberately planted or managed flora” (English Heritage 2008: 71). |
| Event | “Occurrence or change of a particular set of circumstances.” (ISO 2009: sec. 3.5.1.3)<br>N.B.1: “An event can be one or more occurrences, and can have several causes.” (ISO 2009: sec. 3.5.1.3)<br>N.B.2: “The event can be certain or uncertain.” (AS/NZS 2004a: 2)<br>N.B.3: “An event can consist of something not happening.” (ISO 2009: sec. 3.5.1.3) |
| Fabric | “All the physical material of the [*object*] including components, fixtures [and] contents.” (ICOMOS Australia 2013b: art.1.3) |
| Hazard | “A source of potential harm or a situation with a potential to cause loss.” (AS/NZS 2004a: 2) |
| Heritage | See *Cultural Heritage.* |
| Instability | “Lack of physical or chemical equilibrium which could lead to deterioration or loss” (CEN 2011: 9) |
| Intangible cultural heritage | “Practices, representations, expressions, knowledge, skills – as well as the instruments, *objects*, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their *cultural heritage*. [It is] transmitted from generation to generation, constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity.” (UNESCO 2003: art.2)<br>N.B.: “Consideration will be given solely to such intangible *cultural heritage* as is *compatible* with existing international human rights instruments, as well as with the requirements of mutual respect among communities, groups and individuals, and of sustainable development.” (UNESCO 2003: art.2) |
| Integrity | “Extent of physical or conceptual wholeness of an *object*.” (CEN 2011: 8) |
| Interpretation | “All the ways of presenting the *cultural significance* of [an *object*]” (ICOMOS Australia 2013b: art.1.7) |
| Legal Protection | “Provision of legal restraints or controls on the destruction or damaging of |

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| | buildings or artefacts, natural features, systems, sites, areas or other things of acknowledged *value*, with a view to their survival or preservation for the future." (BSI 1998: 3) |
| Likelihood | "chance of something happening" (ISO 2009: sec. 3.6.1.1)<br>N.B.: "In risk management terminology, the word "likelihood" isused to refer to the chance of something happening, whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively, and described using general terms or mathematically [such as a probability or a frequency over a given time period]." (ISO 2009: sec. 3.6.1.1) |
| Maintenance | "Periodic *preventive conservation* actions aimed at sustaining an object in an appropriate *condition* to retain its *significance*." (CEN 2011: 11) |
| Monitoring | "Process of measuring, surveying and assessing the material properties of *objects* and/or factors of the *environment* over time." (CEN 2011: 11)<br>"To check, supervise, observe critically or measure the progress of an activity, action or system on a regular basis in order to identify change from the performance level required or expected" (AS/NZS 2004a: 3) |
| Monument /Deliberate monument | "An artefact, of any nature, form or dimensions, be it a totem pole or a cathedral, marble inscription or wooden panel painting, explicitly constructed by a human group, whatever their importance may be (family or nation, clan or city) with the purpose of remembering and commemorating individuals and events, rites and beliefs that together found their genealogy and their identity. The physical presence of the monument demands and mobilises a living, embodied, organic memory." (Choay 1994: 107) (cf. *Object/Historic monument*) |
| Natural heritage | "Inherited habitats, species, ecosystems, geology and landforms, including those in and under water, to which people attach *value*" (English Heritage 2008: 71). (cf. *Cultural Heritage/Heritage*) |
| Object/ Place/ Heritage object/ Conservation object/ Historic monument | "Single manifestation of *tangible cultural heritage*" (CEN 2011: 7).<br>"embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or an historic event. This applies not only to great works of art but also to more modest works of the past which have acquired *cultural significance* with the passing of time." (ICATHM 1964).<br>This term may refer to immovable or movable cultural heritage assets.<br>N.B.1: Other terms that appear throughout this dissertation with the same meaning include: "artefact"; "asset"; "building"; "cultural property"; "site".<br>N.B.2: "Contrarily to the *monument*, the historic monument is not purposely built for remembrance. It is selected by the educated eye between ancient buildings, be they monuments or not, regardless of any practical end, because of its value for history and for art." (Choay 1994: 107) (cf. *Monument*)<br>N.B.3: *Heritage objects* may be qualified as artistic, historic, scientific, social, archaeological, etc., to highlight a specific dimension when referring to an asset or group thereof. |
| Preventive Conservation | "Measures and actions aimed at avoiding or minimizing future *damage*, *deterioration* and loss and, consequently. any invasive intervention." (CEN 2011: 10)<br>N.B.1: In the field of *built heritage*, *preventive conservation* includes *maintenance, monitoring* and *risk assessment* and *emergency preparedness*.<br>N.B.2: For movable *heritage objects*, the fact that such actions or meauses are indirect is often highlighted; for these objects, "preventive conservation also encompasses correct handling, transport, use, storage and display. It may also involve issues of the production of facsimiles for the purpose of preserving the original." (E.C.C.O. 2002: Preamble) |
| Reconstruction | "Re-establishment of an *object* to an inferred earlier form using existing or replacement material." (CEN 2011: 13)<br>N.B.1: "*Reconstruction* respects the *significance* of the *object* and is based on evidence." (CEN 2011: 13)<br>N.B.2: "*Reconstruction* can be either physical or virtual." (CEN 2011: 13) |

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| Rehabilitation | "*Interventions* on an immovable *object* in order to recover an inferred earlier functionality, to adapt it to a different function or to standards of comfort, safety and access" (CEN 2011: 13)<br>N.B.1: "*Rehabilitation* should be based on assessed evidence including *significance*." (CEN 2011: 13)<br>N.B.2: "*Rehabilitation* is not generally a *conservation* activity but may involve some *conservation* actions." (CEN 2011: 13) |
| Reintegration | "Addition of material in order to facilitate the perception and understanding of an *object*." (CEN 2011: 13)<br>N.B.: "*Reintegration* respects the *significance* of the *object* and is based on evidence." (CEN 2011: 13) |
| Remedial Conservation | "Actions applied directly to an *object* to arrest *deterioration* and/or to limit *damage*." (CEN 2011: 11) |
| Renovation | "Action of renewing an *object* without necessarily respecting its material or *significance"* (CEN 2011: 13)<br>N.B.1: "*Renovation* is not a *conservation* activity." (CEN 2011: 13)<br>N.B.2: "A *renovation* plan, however, may involve some *conservation* actions." (CEN 2011: 13) |
| Repair | "Actions applied to an *object* or part of it to recover its functionality and/or its appearance" (CEN 2011: 13), not necessarily respecting its significance.<br>N.B.: "*Repair* is a *restoration* action only if it respects *significance* and is based on evidence." (CEN 2011: 13) |
| Restoration | "Actions applied to a stable or stabilized *object* aimed at facilitating its appreciation, understanding and/or use, while respecting its *significance*" (CEN 2011: 11) |
| Retreatability | Extent to which a *treatment* performed upon an *object* permits a future treatment of similar nature. |
| Reversibility | "Extent to which a *treatment* can be undone without *damage* to the *object*" (CEN 2011: 10) |
| Risk | "effect of uncertainty on objectives" (ISO 2009: sec. 1.1)<br>N.B.1: "A risk is often specified in terms of an *event* or circumstance and the *consequences* that may flow from it." since "Risk is measured in terms of a combination of the *consequences* of an *event* and their *likelihood*." (AS/NZS 2004a: 4)<br>N.B.2: "Risk may have a positive or negative impact." (AS/NZS 2004a: 4)<br>N.B.3: "Objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organization-wide, project, product and process)" (ISO 2009: sec. 1.1)<br>N.B.4: "Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an *event*, its *consequence*, or *likelihood*." (ISO 2009: sec. 1.1) |
| Risk Analysis | "Systematic process to understand the nature of and to deduce the level of *risk*.<br>[N.B.]: Provides the basis for *risk evaluation* and decisions about risk treatment." (AS/NZS 2004a: 4) |
| Risk Assessment | "The overall process of *risk identification*, *risk analysis* and *risk evaluation*" (ISO 2009: sec. 3.5.1)<br>In Conservation: "Identification, analysis and evaluation of threats that might alter *significance*, and the probability of their occurrence" (CEN 2011: 12) |
| Risk Criteria | "Terms of reference by which the significance of risk is assessed.<br>[N.B.]: Risk criteria can include associated cost and benefits, legal and statutory requirements, socioeconomic and environmental aspects, the concerns of *stakeholders*, priorities and other inputs to the assessment." (AS/NZS 2004a: 4) |
| Risk Evaluation | "Process of comparing the level of risk against *risk criteria*" (AS/NZS 2004a: 4)<br>N.B.: Risk evaluation assists in decisions about *risk treatment*" (AS/NZS 2004a: 4) |
| Risk Identification | "The process of determining what, where, when, why and how something could happen." (AS/NZS 2004a: 4) |

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| Risk Source | "element which alone or in combination has the intrinsic potential to give rise to *risk*.<br>[N.B.:] A risk source can be tangible or intangible." (ISO 2009: sec. 3.5.1.2) |
| Risk treatment | "Process of selection and implementation of measures to modify risk" (AS/NZS 2004a: 5) |
| Significance/ Cultural Significance | "Combination of all the *values* assigned to an *object*" (CEN 2011: 8)<br>N.B.: Because selecting an entity of significance is a cultural behaviour, the terms *Significance* and *Cultural significance* are considered interchangeable throughout this document and used accordingly. |
| Stakeholders/ Heritage Community | "People who value specific aspects of cultural heritage which they wish, within the framework of public action, to sustain and transmit to future generations." (COE 2005, art. 2b)<br>"Those people and organizations who may affect, be affected by, or perceive themselves to be affected by a decision, activity or *risk*." (AS/NZS 2004a: 6) |
| Statement of Significance | Report on the *significance* assessment of an *object*, dated and authored, "expressing simply why the [object] is of *value*" (ICOMOS Australia 2013b: art.1.4); i.e., "a reasoned, readable summary of the values, meaning and importance of an item or collection." (Russell & Winkworth 2009: 11)<br>N.B.1: "A statement of significance is a reference point for all the policies, actions and decisions about how the item is managed. It is a means of sharing knowledge about why an item is important, and why it has a place in a public collection." (Russell & Winkworth 2009: 11)<br>N.B.2: The statement should list conclusions and identify unresolved issues, as well as be supported by pertinent and verified data. |
| Sustainability | Extent to which the needs of the present are met without compromising the ability of future generations to meet their own needs. (Adapted from the Brundtland Report (1987))<br>N.B.: Principles for the sustainable use of *cultural heritage* in Europe may be found in the Faro Convention (COE 2005: art.9) and include: "Promote respect for the integrity of the *cultural heritage* by ensuring that decisions about change include an understanding of the cultural *values* involved." (COE 2005: art.9a) |
| Tangible cultural heritage | "Material expression of *cultural heritage*." (CEN 2011: 7)<br>Note: *Tangible cultural heritage* can be movable or immovable. |
| Treatment procedure/ Intervention | "Direct action carried out on an *object*" (CEN 2011: 12) |
| Valorization | "addition of *value*" (Mason 1998: 6) |
| Valuation/valuing | "An estimation of the worth of something, especially one carried out by a professional valuer; the monetary worth of something, especially as estimated by a valuer" (OED) (see *Value assessment*) |
| Value | "Aspect of importance that individuals or a society assign(s) to an *object*" (CEN 2011: 8)<br>NB.: "The assigned *value* can change according to circumstance, e.g. how the judgement is made, the *context* and the moment in time. *Value* should always be indicated by its qualifying type [e.g. artistic, economic, historical, symbolic, scientific, social, etc.]" (CEN 2011: 8) |
| Value or Significance assessment | Appraisal of the ensemble of *values* ascribed to a *heritage object*. Depending on the adopted value system, the assessment may or may not include monetary/economic values. (see *Valuation*) |
| Vulnerability | "intrinsic properties of something resulting in susceptibility to a *risk source* that can lead to an *event* with a *consequence*" (ISO 2009: sec. 3.6.1.6) |
| Weathering | "*Alteration* due to exposure to outdoor *environment*" (CEN 2011: 9) |

# Bibliographic references


AA.VV. (2007). *Cultural Heritage and Natural Disasters: Risk Preparedness and the Limits of Prevention (Heritage at Risk Special Edition) - Proceedings of the ICOMOS International Conference*. H.-R. Meier, M. Petzet & T. Will (Eds.). Leipzig: ICOMOS Germany & TU Dresden.

AA.VV. (2012). *Tangible Risks, Intangible Opportunities: Long-term Risk Preparedness and Responses for Threats to Cultural Heritage - Reducing Risks to Cultural Heritage from Natural and Human-Caused Disasters - Proceedings of the ICOMOS Advisory Committee Scientific Symposium*. A. Chabbi, P. Jerome, R. Jigyasu, S. J. Kelley & J. K. Reap (Eds.). Beijing: ICOMOS China.

AA.VV. (2013). *Tangible Risks, Intangible Opportunities: Long-term Risk Preparedness and Responses for Threats to Cultural Heritage - Reducing Risks to Cultural Heritage from Uncontrolled Development in a Globalized World - Proceedings of the ICOMOS Advisory Committee Scientific Symposium*. S. Avgerinou-Kolonias, M. C. Ocampo & G. B. Pérez (Eds.). San José: ICOMOS.

Abidin, Z. Z. (1999). *The identification of criteria and indicators for the sustainable management of ecotourism in Taman Negara National Park, Malaysia: A Delphi consensus.* PhD Dissertation, West Virginia University, Morgantown.

Adam, R. (2008). Heritage. In M. Hardy (Ed.), *The Venice Charter revisited: modernism, conservation and tradition in the 21st century* (pp. 3-15). Newcastle upon Tyne: Cambridge Scholars.

AIC. (2014). Definitions of Conservation Terminology. Retrieved March 26th 2015, from http://www.conservation-us.org/about-conservation/related-organizations/definitions#.VRRFiY473EE

Aires-Barros, L. (2001). *As Rochas dos Monumentos Portugueses: Tipologias e Patologias*. Lisbon: IPPAR - Instituto Português do Património Arquitectónico.

Alakomi, H. L., Saarela, M., Gorbushina, A. A., Krumbein, W. E., McCullagh, C., Robertson, P., et al. (2006, 21-24 June). *Control of biofilm growth through photodynamic treatments combined with chemical inhibitors: in vitro evaluation methods.* Paper presented at the Heritage, Weathering and Conservation (HWC-2006). R. Fort, M. Alvarez de Buergo, M. Gomez-Heras & C. Vazquez-Calvo (Eds.), Vol. II, pp. 713-717. Madrid: Taylor and Francis.

Alessandrini, G., Peruzzi, R., Toniolo, L. & Pasetti, A. (1995). Pulitura di superfici lapidee: parametri e metodologie per la valutazione della nocività dei trattamenti. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 589-600). Padova: Libreria Progetto Editore.

Álvarez de Buergo, M., Ascaso, C., de los Ríos, A., Gómez-Heras, M., Pérez Ortega, S., Fort, R., et al. (2013). *Assessment of laser treatment on dolostones colonized by microorganisms and lichens.* Paper presented at the International Congress on Science and Technology for the Conservation of Cultural Heritage. M. A. Rogerio-Candelera, M. Lazzari & E. Cano (Eds.), pp. 173-177. Santiago de Compostela: CRC Press.

Andrew, C. (2002). Perception and aesthetics of weathered stone façades. In R. Přikryl & H. Viles (Eds.), *Understanding and Managing of Stone Decay* (pp. 331-339). Prague: The Karolinum Press.

Andrew, C., Young, M. & Tonge, K. H. (1994). *Stone Cleaning: A Guide for Practitioners*. Edinburgh: Historic Scotland & Robert Gordon University.

Appelbaum, B. (1987). Criteria for treatment: reversibility. *Journal of the American Institute for Conservation, 26*(2), 65-73. doi:10.1179/019713687806027852

Appelbaum, B. (2010). *Conservation Treatment Methodology* (2nd ed.): Author's edition.

AS/NZS. (2004a). AS/NZS 4360:2004 - Risk Management. Sydney/Wellington: Standards Australia International/Standards New Zealand.

AS/NZS. (2004b). *Risk Management Guidelines Companion to AS/NZS 4360:2004*. Sydney: Standards Australia Internal Ltd, Sydney.

Ashley-Smith, J. (1999). *Risk Assessment for Object Conservation*. Oxford: Butterworth-Heinemann.

Ashley-Smith, J. (2001). Practical uses of risk analysis. *The Paper Conservator, 25*(1), 59-63. doi:10.1080/03094227.2001.9638681

Ashley-Smith, J. (2009). The basis of conservation ethics. In A. Richmond & A. Bracker (Eds.), *Conservation: Principles, Dilemmas and Uncomfortable Truths* (pp. 6-24). London: Butterworth-Heinemann / V&A Museum.

Ashurst, J. (1990). Cleaning masonry buildings. In J. Ashurst & F. G. Dimes (Eds.), *Conservation of Building and Decorative Stone* (Vol. 2, pp. 125-134). London: Butterworth-Heineman.

Ashurst, N. (1994a). *Cleaning Historic Buildings* (Vol. 2: Cleaning Materials and Processes). Shaftesbury: Donhead.

Ashurst, N. (1994b). *Cleaning Historic Buildings* (Vol. 1: Substrates, Soiling and Investigations). Shaftesbury: Donhead.

Atakul, N., Thaheem, M. J. & De Marco, A. (2014). Risk management for sustainable restoration of immovable cultural heritage, part 1: PRM framework. *Journal of Cultural Heritage Management and Sustainable Development, 4*(2), 149-165. doi:10.1108/JCHMSD-12-2012-0068

Avrami, E., Mason, R. & de la Torre, M. (2000). *Values and Heritage Conservation - Report on Research*. Los Angeles: The Getty Conservation Institute.

Baer, N. S. (1989, 13-16 June). *Assessment and management of risks to cultural property.* Paper presented at the Science, Technology and European Cultural Heritage. N. S. Baer, C. Sabbioni & A. I. Sors (Eds.), pp. 27-36. Bologna: Butterworth-Heinemann Publishers for the Commission of European Communities.

Báez, A. & Herrero, L. C. (2012). Using contingent valuation and cost-benefit analysis to design a policy for restoring cultural heritage. *Journal of Cultural Heritage, 13*(3), 235-245. doi:10.1016/j.culher.2010.12.005

Baldi, P., Giovagnoli, A., Marabelli, M. & Coppi, R. (1995). Models and methods for the construction of risk maps for cultural heritage. *Statistical Methods & Applications, 4*(1), 1-15. doi:10.1007/BF02589056

Becherini, F., Bernardi, A., Vivarelli, A., Pockelé, L., de Grandi, S., Gandini, A., et al. (2013). *Environmental risks assessment and preventive conservation strategy for the Pórtico de la Gloria, Santiago de Compostela Cathedral.* Paper presented at the Science and Technology for the Conservation of Cultural Heritage. M. A. Rogerio-Candelera, M. Lazzari & E. Cano (Eds.), pp. 5-9. Santiago de Compostela: CRC Press.

Biscontin, G., Zendri, E., Bakolas, A., Longega, G., Driussi, G. & Moropoulou, A. (1995). Alcune considerazioni sulla pulitura dell superfici architettoniche. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 625-631). Padova: Libreria Progetto Editore.

Biscontin, G., Zendri, E., Bakolas, A., Polloni, R., Calvelli, P. & Moropoulou, A. (1995). Valutazione degli effetti della pulitura mediante laser su alcuni supporti lapidei carbonatici. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 547-564). Padova: Libreria Progetto Editore.

Bluestone, D., Klamer, A., Throsby, D. & Mason, R. (1998, 1999). *The economics of heritage conservation: a discussion.* Paper presented at the Economics and Heritage Conservation – Report of a Meeting Organized by the Getty Conservation Institute. M. de la Torre & R. Mason (Eds.), pp. 19-22. Los Angeles: The Getty Conservation Institute.

Boito, C. (2000). *Conserver ou Restaurer - Les Dilemmes du Patrimoine* (J.-M. Mancosio, Trans.). Besançon: Les Éditions de L'Imprimeur.

Bonini, N. (2007). Decision anomalies and psychology of decision making. In R. VAROLI-PIAZZA (Ed.), *Sharing Conservation Decisions* (pp. 34-37). Rome: ICCROM.

Bonsanti, G. (2003, 13-14 June). *L'illusione chimica e la compatibilità dei materiali.* Paper presented at the Convegni 'Dalla Reversibilità alla Compatibilità', pp. 3-11. Conegliano: Nardini Editore.

Borghese, B. (2015, October). To clean or not to clean? That's Anish Kapoor's dilemma. *News in Conservation*. Retrieved from https://www.iiconservation.org/system/files/publications/journal/2015/b2015_5.pdf

Bourguignon, E., Bertrand, F., Moreau, C., Coussot, P. & Shahidzadeh-Bonn, N. (2008, 15–20 September 2008). *Desalination of model stones by poulticing.* Paper presented at the 11th International Congress on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. II, pp. 803-810. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University.

Bowitz, E. & Ibenholt, K. (2009). Economic impacts of cultural heritage – Research and perspectives. *Journal of Cultural Heritage, 10*(1), 1-8. doi:10.1016/j.culher.2008.09.002

Brajer, I. (2009). Taking the wrong path: learning from oversights, misconceptions, failures and mistakes in conservation.. Examples from wall painting conservation in Denmark. *CeROArt. Conservation, exposition, Restauration d'Objets d'Art, 3*. Retrieved from http://ceroart.revues.org/1127

Brandi, C. (1996). Readings from "Theory of Restoration" (G. PONTI & A. M. VACCARO, Trans.). In N. S. Price, J. M.K. Talley & A. M. Vaccaro (Eds.), *Historical and Philosophical Issues in the Conservation of Cultural Heritage* (pp. 230-235; 339-342; 377-379). Los Angeles: The Getty Conservation Institute.

Brimblecombe, P. (2013). *Environmental assessment and monitoring of cultural heritage.* Paper presented at the Science and Technology for the Conservation of Cultural Heritage. M. A. Rogerio-Candelera, M. Lazzari & E. Cano (Eds.), pp. 1-4. Santiago de Compostela: CRC Press.

Bromblet, P. (1999). *Properties and durability of air-based lime mortars for limestone repairs on monuments.* Paper presented at the Workshop on Historic Mortars: Characteristics and Tests. P. Bartos, C. Groot & J. J. Hughes (Eds.), pp. 327-338. Paisley: RILEM.

Brooks, M. M. & Eastop, D. (2006). Matter out of place: paradigms for analyzing textile cleaning. *Journal of the American Institute for Conservation, 45*(3), 171-181. Retrieved from www.jstor.org/stable/40026689

Brundtland, G. H. (1987). Our Common Future: Report of the World Commission on Environment and Development (A/42/427) by the Brundtland Commission of the World Commission on Environment and Development. Retrieved October 2008, from http://www.un-documents.net/ocf-02.htm#I

BSI. (1998). BS 7913: 1998: Guide to the Principles of the Conservation of Historic Buildings. London: British Standards Institution.

BSI. (2000). BS 8221-1: 2000: Code of practice for cleaning and surface repair of buildings. Part 1: Cleaning of natural stones, brick, terracotta and concrete. London: British Standards Institution.

Burman, P. A. T. I. (2001). What is cultural heritage? In N. S. Baer & F. Snickars (Eds.), *Rational Decision-making in the Preservation of Cultural Property - Dahlem Workshop Report 86* (pp. 11-22). Berlin: Dahlem University Press.

CAC & CAPC. (2009). Code of Ethics and Guidance for Practice of the Canadian Association for Conservation of Cultural Property and of the Canadian Association of Professional Conservators (3rd ed.). Ottawa: CAC & CAPC.

Caldeira, L. (2005). Análises de Riscos em Geotecnia. Aplicação a Barragens de Aterro [Risk Analysis in Geotechnical Engineering. Its Application to Embankment Dams], *Programas de Investigação e de Pós-Graduação na Área Científica de Mecânica dos Solos, apresentados para obtenção do título de Habilitado para o Exercício das Funções de Coordenação Científica*. Lisbon: LNEC.

Cane, S., Slarke, D., Ashley-Smith, J., Robinson, S. & Pollard, T. (2011). *Developing a High-Level Risk Assessment Tool for Heritage Assets.* Paper presented at the ICOM-CC 16th Triennial Conference. J. Bridgland (Ed.). Lisbon: ICOM-CC (CD-ROM preprints).

Cappelletti, G., Fermo, P., Pino, F., Pargoletti, E., Pecchioni, E., Fratini, F., et al. (2015). On the role of hydrophobic Si-based protective coatings in limiting mortar deterioration. *Environmental Science and Pollution Research, 22*(22), 17733-17743. doi:10.1007/s11356-015-4962-0

Carson, R. T., Conaway, M. B. & Navrud, S. (2013). Preliminary valuation of a cultural heritage site of global significance: a Delphi contingent valuation study. In I. Rizzo & A. Mignosa (Eds.), *Handbook on the Economics of Cultural Heritage* (pp. 586-604). Cheltenham: Edward Elgar Publishing Ltd.

Carver, M. (2013). On Archaeological Value (1996). In S. Sullivan & R. Mackay (Eds.), *Archaeological Sites: Conservation and Management* (pp. 295-312). Los Angeles: The Getty Conservation Institute.

CEN. (2011). *EN 15898:2011 - Conservation of cultural property - Main general terms and definitions*. Brussels: European Committee for Standardization.

CHAN. (2015). Listed monuments.*Cultural heritage in the Netherlands.*Cultural Heritage Agency of the Netherlands (CHAN). Retrieved January 18, 2015, from http://culturalheritageagency.nl/en/listed-monuments

Chapman, S. (2000). Laser technology for graffiti removal. *Journal of Cultural Heritage, 1*, S75-S78.

Charola, A. E. & Henriques, F. M. A. (1998). *Lime mortars: some considerations on testing stantardization.* Paper presented at the Use of and Need for Preservation Standards in Architectural Conservation, ASTM STP 1355. R. C. McClung (Ed.): American Society for Testing Materials.

Choay, F. (1984). Introduction *Le Culte Moderne des Monuments: Son Essence et Sa Genèse*. Paris: Éditions du Seuil.

Choay, F. (1994). *Sept propositions sur le concept d'authenticité.* Paper presented at the Nara Conference on Authenticity. K. E.Larsen (Ed.), pp. 101-120. Nara: UNESCO / Japanese Agency for Cultural Affairs / ICCROM / ICOMOS.

Choay, F. (2000a). *A Alegoria do Património [L'Allégorie du Patrimoine]* (T. Castro, Trans.). Lisboa: Edições 70.

Choay, F. (2000b). Prélude *Conserver ou Restaurer - Les Dilemmes du Patrimoine*. Besançon: Les Éditions de L'Imprimeur.

Choay, F. (2011). *As Questões do Património - Antologia para um Combate [Le Patrimoine en Questions. Anthologie pour un Combat]* (L. F. Sarmento, Trans.). Lisboa: Edições 70.

Churchill, W. (October 1943). Address to the Commons Chamber. Retrieved May 2015, from http://www.parliament.uk/about/living-heritage/building/palace/architecture/palacestructure/churchill/

COE. (2005). Faro Convention - Framework Convention on the Value of Cultural Heritage for Society.*Council of Europe Treaty Series - No. 199* Retrieved February 9th 2012, from http://www.coe.int/t/dg4/cultureheritage/heritage/Identities/Faro2_en.asp

Concha-Lozano, N., Gaudon, P., Pages, J., De Billerbeck, G., Lafon, D. & Eterradossi, O. (2012). Protective effect of endolithic fungal hyphae on oolitic limestone buildings. *Journal of Cultural Heritage, 13*(2), 120-127. doi:10.1016/j.culher.2011.07.006

Concha-Lozano, N., Lafon, D., Sabiri, N. & Gaudon, P. (2013). Color thresholds for aesthetically compatible replacement of stones on monuments. *Color Res. Appl., 38*, 356-363. doi:10.1002/col.21729

Darvill, T. (1994). Value systems and the archaeological resource. *International Journal of Heritage Studies, 1*(1), 52-64. doi:10.1080/13527259408722130

De Bruin, G. (2004). An assessment of Deltaplan: the Dutch national preservation strategy. *Liber quarterly, 14*(3-4), 356-367. doi:10.18352/lq.7787

De Clercq, H. & Godts, S. (2014, 14-16 October). *Salt extractions of brickwork: a standard procedure?* Paper presented at the SWBSS 2014 - Third International Conference on Salt Weathering of Buildings and Stone Sculptures. H. De Clercq (Ed.), pp. 457-467. Brussels: Koninkljik Instituut voor het Kunstpatrimonium (KIK) - Institut Royal du Patrimoine Artistique (IRPA).

De Clercq, H., Vanhellemont, Y. & De Swaef, V. (2014, 14-16 October). *Salt extraction of limestone by means of electrophoresis: some results on type of contact material and electrode position.* Paper presented at the SWBSS 2014 - Third International Conference on Salt Weathering of Buildings and Stone Sculptures. H. De Clercq (Ed.), pp. 421-434. Brussels: Koninkljik Instituut voor het Kunstpatrimonium (KIK) - Institut Royal du Patrimoine Artistique (IRPA).

de la Torre, M., Mac Lean, M. G. H., Mason, R. & Myers, D. (2005). *Heritage Values in Site Management: Four Case Studies*. Los Angeles: Getty Publications.

De Muynck, W., Verbeken, K., De Belie, N. & Verstraete, W. (2010). Influence of urea and calcium dosage on the effectiveness of bacterially induced carbonate precipitation on limestone. *Ecological Engineering, 36*(2), 99-111. doi:10.1016/j.ecoleng.2009.03.025

de Oliveira, C., Bromblet, P., Colombini, A. & Vergès-Belmin, V. (2015). Medium-wave ultraviolet radiation to eliminate laser-induced yellowing generated by the laser removal of lamp black on gypsum. *Studies in Conservation, 60*(S1), S34-S40. doi:10.1179/0039363015Z.000000000205

*Decreto-lei 25/37*, Presidência da República dos Estados Unidos do Brasil (1937).

Deeben, J., Groenewoudt, B. J., Hallewas, D. P. & Willems, W. J. (1999). Proposals for a practical system of significance evaluation in archaeological heritage management. *European Journal of Archaeology, 2*(2), 177-199.

Dei, L. (2013). Conservation Treatments: Cleaning, Consolidation and Protection. In P. Baglioni & D. Chelazzi (Eds.), *Nanoscience for the Conservation of Works of Art* (Vol. 28, pp. 77-92). Cambridge: The Royal Society of Chemistry.

Del Monte, M. (1991). The cultural heritage: causes of damage. In N. S. Baer, C. Sabbioni & A. I. Sors (Eds.), *Science, Technology and European Cultural Heritage: Proceedings of the European Symposium* (pp. 78-89). Bologna: Butterworth-Heinemann Publishers for the Commission of European Communities.

Delegou, E. T., Avdelidis, N. P., Karaviti, E. & Moropoulou, A. (2008). NDT&E techniques and SEM-EDS for the assessment of cleaning interventions on Pentelic marble surfaces. *X-Ray Spectrometry, 37*(4), 435-443.

Delegou, E. T., Kiranoudis, C., Sayas, J. & Moropoulou, A. (2012). *Developing an integrated decision making system for the assessment of cleaning interventions on marble architectural surfaces.* Paper presented at the 12th International Congress on Deterioration and Conservation of Stone. Columbia University, New York

Delegou, E. T. & Moropoulou, A. (2008, 15–20 September 2008). *Evaluation criteria & decision making on cleaning interventions of marble surfaces.* Paper presented at the 11th International Congress on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. II, pp. 1179-1188. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University.

Delgado Rodrigues, J. (1978, 5-9 june). *Some problems raised by the study of the weathering of igneous rocks.* Paper presented at the Alteration et protection des monuments en pierre: colloque international. Deterioration and protection of stone monuments: international symposium. Paris

Delgado Rodrigues, J. (1988). Proposed geotechnical classification of carbonate rocks based on Portuguese and Algerian examples. *Engineering Geology, 25*, 33-43.

Delgado Rodrigues, J. (2001). Swelling behaviour of stones and its interest in conservation. An appraisal. *Materiales de Construcción, 51*(263-264), 183-195. doi:10.3989/mc.2001.v51.i263-264.363

Delgado Rodrigues, J. (2006). *Stone patina. A controversial concept of relevant importance in conservation.* Paper presented at the International Seminar "Theory and Practice in Conservation: a Tribute to Cesare Brandi". J. Delgado Rodrigues & J. M. Mimoso (Eds.), pp. 127-138. Lisbon: LNEC.

Delgado Rodrigues, J. (2007). *Ciência e prática em conservação e restauro*. Paper presented at the Cesare Brandi: Teoria e Praxis no Restauro Arquitectónico International Seminar. Retrieved from http://mestrado-reabilitacao.fa.utl.pt/seminario/DELGADO.pdf

Delgado Rodrigues, J., Alessandrini, G. & Bouinneau, A. (1997). *Procedure for selection and control of cleaning operations. A proposal.* Paper presented at the Fourth International Symposium on the Conservation of Monuments in the Mediterranean. A. Moropoulou, F. Zezza, E. Kollias & I. Papachristodoulou (Eds.), pp. 337–345. Rodhes: Technical Chamber of Greece.

Delgado Rodrigues, J. & Castro, E. (1989). *Some remarks on the efficacy and harmfulness of stone cleaning.* Paper presented at the The Conservation of Monuments in the Mediterranean Basin - 1st International Symposium. F. Zezza (Ed.), Vol. 1, pp. 491-494. Bari: Grafo.

Delgado Rodrigues, J., Costa, D., Mascalchi, M., Osticioli, I. & Siano, S. (2014). Laser ablation of iron-rich black films from exposed granite surfaces. *Appl. Phys. A, 117*, 365-370. doi:10.1007/s00339-014-8470-8

Delgado Rodrigues, J. & Grossi, A. (2004). *The Compatibility Approach* (Deliverable No. 03): INCO: International Scientific Cooperation Projects (1998-2002) Contract No ICA3-CT-2002-10021.

Delgado Rodrigues, J. & Grossi, A. (2007). Indicators and ratings for the compatibility assessment of conservation actions. *Journal of Cultural Heritage, 8*, 32-43. doi:101016/j.culher.2006.04.007

Delgado Rodrigues, J. & Valero, J. (2003). A brief note on the elimination of dark stains of biological origin. *Studies in Conservation, 48*(1), 17-22.

Demas, M. (2002). Planning for conservation and management of archaeological sites: a values-based approach. In G. Palumbo & J. M. Teutonico (Eds.), *Management Planning for Archaeological Sites* (pp. 27-54). Los Angeles: The Getty Conservation Institute.

Dessandier, D. (2000). Guide méthodologique de sélection des pierres des monuments en termes de durabilîté et compatibilité, BRGM/RP-50137.FR: BRGM. Available from http://infoterre.brgm.fr/rapports/RP-50137-FR.pdf

Doehne, E. & Price, C. A. (2010). *Stone Conservation: An Overview of Current Research (2nd Edition)*. Los Angeles: The Getty Conservation Institute.

Doehne, E., Schiro, M., Roby, T., Chiari, G., Lambousy, G. & Knight, H. (2008, 15–20 September 2008). *Evaluation of poultice desalination process at Madame Johns' Legacy, New Orleans.* Paper presented at the 11th International Congress on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. II, pp. 857-864. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University.

Domasłowski, W. & Kwiatkowski, D. (2003). Removal of surface deposit. In W. Domasłowski (Ed.), *Preventive Conservation of Stone Objects* (pp. 117-159). Toruń: Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika.

Ďoubal, J. (2014). Research into methods of cleaning silicate sandstones used for historical monuments. *Journal of Architectural Conservation, 20*(2), 123-138.

Dümcke, C. & Gnedovsky, M. (2013). *The social and economic value of cultural heritage: literature review*: Directorate-General for Education and Culture of the European Commission (DG EAC) - European Expert Network on Culture (EENC).

E.C.C.O. (2002). E.C.C.O. Professional Guidelines (I): The Profession.*E.C.C.O. PROFESSIONAL GUIDELINES - Promoted by the European Confederation of Conservator-Restorers' Organisations and adopted by its General Assembly* Retrieved Feb 14th 2012, from http://www.encore-edu.org/ecco1.html?tabindex=3&tabid=170

E.C.C.O. (2003). E.C.C.O. Professional Guidelines (II).*E.C.C.O. PROFESSIONAL GUIDELINES - Promoted by the European Confederation of Conservator-Restorers' Organisations and adopted by its General Assembly* Retrieved Feb 14th 2012, from http://www.encore-edu.org/ecco2.html

EHP. (2013). *Assessing cultural heritage significance: using the cultural heritage criteria*. Queensland Department of Environment and Heritage Protection (EHP). Retrieved from http://www.qldheritage.org.au/assets/files/pdf/using-the-criteria.pdf.

Elsorady, D. A. (2014). Assessment of the compatibility of new uses for heritage buildings: The example of Alexandria National Museum, Alexandria, Egypt. *Journal of Cultural Heritage, 15*(5), 511-521. doi:10.1016/j.culher.2013.10.011

English Heritage. (2008). Principles, Policies and Guidance for the Sustainable Management of the Historic Environment. Retrieved November 14th 2011, from http://www.english-heritage.org.uk/publications/conservation-principles-sustainable-management-historic-environment/conservationprinciplespoliciesguidanceapr08web.pdf

Epstein, R. A. (2003). The regrettable necessity of contingent valuation. *Journal of Cultural Economics, 27*(3), 259-274.

Esbert, R. M., Grossi, C. M., Rojo, A., Alonso, F. J., Montoto, M., Ordaz, J., et al. (2003). Application limits of Q-switched Nd:YAG laser irradiation for stone cleaning based on colour measurements. *Journal of Cultural Heritage, 4*, 50s–55s.

FAO/WHO. (2009). Risk Characterization of Microbiological Hazards in Food: Guidelines, Microbiological Risk Assessment Series Nr.17. Rome: Food and Agriculture Organization of the United Nations/World Health Organization. Available from http://www.fao.org/docrep/012/i1134e/i1134e00.htm

Fassina, V. (1993). General criteria for the cleaning of stone: theoretical aspects and methodology of application. In F. Zezza (Ed.), *Stone Material in Monuments: Diagnosis and Conservation; Scuola Universitaria C.U.M. Conservazione dei Monumenti; Heraklion, Crete* (pp. 126-132). Bari: Mario Adda Editore.

Feijoo, J., Nóvoa, X. R., Rivas, T., Mosquera, M. J., Taboada, J., Montojo, C., et al. (2013). Granite desalination using electromigration. Influence of type of granite and saline contaminant. *Journal of Cultural Heritage, 14*(5), 365-376. doi:10.1016/j.culher.2012.09.004

Feilden, B. M. (1993). Is conservation of cultural heritage relevant to South Asia? *South Asian Studies, 9*(1), 1-10.

Feilden, B. M. (2003). *Conservation of Historic Buildings*. Oxford: Architectural Press.

Fratini, F., Manganelli Del Fà, C., Pecchioni, E. & Raddi, G. (1995). Effetti di pulitura su superfici marmoree: valutazione mediante analisi microscopica. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 531-538). Padova: Libreria Progetto Editore.

Fredd, C. N. & Folger, H. S. (1998). The influence of chelating agents on the kinetics of calcite dissolution. *Journal of Colloid and Interface Science, 204*, 187-197.

Freire, M. T., Veiga, M. R., Santos Silva, A. & Brito, J. (2015). *Desenvolvimento de produtos compatíveis de gesso e cal para a conservação e restauro de estuques antigos*. Paper presented at the CONPAT 2015.

Galán, E. & Aparicio, P. (2013, 18-20 November). *The environmental risk assessment applied to cultural heritage. A methodological approach.* Paper presented at the Built Heritage 2013 - Monitoring Conservation and Management Conference. M. Boriani, R. Gabaglio & D. Gulotta (Eds.), pp. 1405-1409. Milan: Politecnico di Milano, Centro per la Conservazione e Valorizzazione dei Beni Culturali.

Galán, E., González, J. B. & Ávila, R. M. (2006). La aplicación de la evaluación de impacto ambiental en el patrimonio monumental y el desarrollo sostenible de las ciudades. *Revista de Enseñanza Universitaria*(1), 123-140.

García, O. & Malaga, K. (2012). Definition of the procedure to determine the suitability and durability of an anti-graffiti product for application on cultural heritage porous materials. *Journal of Cultural Heritage, 13*, 77-82. doi:10.1016/j.culher.2011.07.004

Garrod, B. & Fyall, A. (2000). Managing Heritage Tourism. *Ann. Tourism Res., 27*(3), 682-708.

Gaspar, P., Hubbard, C., McPhail, D. & Cummings, A. (2003). A topographical assessment and comparison of conservation cleaning treatments. *Journal of Cultural Heritage, 4*, 294s-302s.

Gauri, K. L. & Chowdhury, A. N. (1988, 12-14 September). *Experimental studies on conversion of gypsum to calcite by microbes.* Paper presented at the 6th International Congress on Deterioration and Conservation of Stone, pp. 545-550. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University Press Department.

Gawande, A. (2007, December 10). The Checklist. *The New Yorker*. Retrieved from http://www.newyorker.com/magazine/2007/12/10/the-checklist

Gerrow, C. M., Gerdwilker, C., Warke, P. A., McCabe, S. & McKinley, J. M. (2014). *Poulticing sandstone: implications for subsequent weathering response.* Paper presented at the SWBSS 2014 - Third International Conference on Salt Weathering of Buildings and Stone Sculptures. H. De Clercq (Ed.), pp. 435-455. Brussels: Koninkljik Instituut voor het Kunstpatrimonium (KIK) - Institut Royal du Patrimoine Artistique (IRPA).

Gervais, C., Grissom, C. A., Little, N. & Wachowiak, M. J. (2010). Cleaning marble with ammonium citrate. *Studies in Conservation, 55*, 164–176. doi:10.1179/sic.2010.55.3.164

Gilman, R. (2015). Tornos - uma escatologia Turístico-Patrimonial. *Revista Punkto,* (Fevereiro 2015). Retrieved from http://www.revistapunkto.com/2015/02/tornos-uma-escatologia-turistico_23.html

Gizzi, F. T. (2008). Identifying geological and geotechnical influences that threaten historical sites: A method to evaluate the usefulness of data already available. *Journal of Cultural Heritage, 9*(3), 302-310. doi:10.1016/j.culher.2007.11.002

Green, H. L. (1997, March 20-22). *The social construction of historical significance.* Paper presented at the Preservation of What, for Whom? A Critical Look at Historical Significance. M. A. Tomlan (Ed.), pp. 85-94. Baltimore: The National Council for Preservation Education.

Grimmer, A. E. (1979). Dangers of Abrasive Cleaning to Historic Buildings, *Preservation Brief 6*. Washington D.C.: US Department of the Interior, Heritage Conservation and Recreation Service [Office of Archeology and Historic Preservation], Technical Preservation Services Division.

Grossi, A. (2005). *Compatibility Decision Support System design - Section One: Overview of the system* (Deliverable No. 10): INCO: International Scientific Cooperation Projects (1998-2002) Contract No ICA3-CT-2002-10021.

Guidetti, V. & Uminski, M. (2000, June 19-24). *Ion Exchange Resins for Historic Marble Desulfatation and Restoration.* Paper presented at the 9th International Congress on Deterioration and Conservation of Stone. V. Fassina (Ed.), Vol. 2, pp. 327-333. Venice: Elsevier Science B.V.

Gulotta, D., Saviello, D., Gherardi, F., Toniolo, L., Anzani, M., Rabbolini, A., et al. (2014). Setup of a sustainable indoor cleaning methodology for the sculpted stone surfaces of the Duomo of Milan. *Heritage Science, 2*(1), 6.

Hansson, S. O. (2014). «Risk». The Stanford Encyclopedia of Philosophy (Spring 2014 Edition). E. N. Zalta (Ed.). Available from http://plato.stanford.edu/archives/spr2014/entries/risk/

Hassler, U. & Kohler, N. (2001). Cultural and environmental long term strategies for the built environment. In N. S. Baer & F. Snickars (Eds.), *Rational Decision-making in the Preservation of Cultural Property - Dahlem Workshop Report 86* (pp. 235-248). Berlin: Dahlem University Press.

Hauff, G., Kozub, P. & D'ham, G. (2008, 15–20 September). *Which cleaning system is the most appropriate one? A systematic approach to the assessment of cleaning test panels.* Paper presented at the 11th International Conference on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. I, pp. 381-388. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University.

Heritage Victoria. (2001). Walls/Cleaning Masonry. Retrieved August 2013, from http://www.dtpli.vic.gov.au/__data/assets/pdf_file/0007/219346/CleanMasonry.pdf

Historic Scotland. (2000). *Conservation plans: a guide to the preparation of conservation plans*: Historic Scotland.

Hsu, C. C. & Sandford, B. A. (2007). The Delphi technique: making sense of consensus. *Practical Assessment, Research & Evaluation, 12*, article 10.

HWMPC. (2008). *Hadrian's Wall Management Plan 2008-2014*. Hadrian's Wall Management Plan Committee. Retrieved from www.hadrians-wall.org.

Ibáñez, A. J. P., Bernal, J. M. M., de Diego, M. J. C. & Sánchez, F. J. A. (2016). Expert system for predicting buildings service life under ISO 31000 standard. Application in architectural heritage. *Journal of Cultural Heritage, 18*, 209–218. doi:10.1016/j.culher.2015.10.006

ICATHM. (1964). The Venice Charter - International Charter for the Conservation and Restoration of Monuments and Sites. Retrieved October 2008, from http://www.international.icomos.org/charters/venice_e.htm

ICC Krakow. (2000). The Charter of Krakow - Principles for Conservation and Restoration of Built Heritage. Retrieved July 2007, from http://lecce-workshop.unile.it/Downloads/The%20Charter%20of%20Krakow%202000.pdf

ICOMOS-ISCS. (2008). Illustrated Glossary on Stone Deterioration Patterns. Retrieved January 28th 2013, from http://www.icomos.org/publications/monuments_and_sites/15/pdf/Monuments_and_Sites_15_ISCS_Glossary_Stone.pdf

ICOMOS Americas. (1996). The Declaration of San Antonio: Authenticity in the Conservation and Management of the Cultural Heritage. Retrieved March 19th 2015, from http://www.icomos.org/en/charters-and-texts/179-articles-en-francais/ressources/charters-and-standards/188-the-declaration-of-san-antonio

ICOMOS Australia. (1979). The Australia ICOMOS Guidelines for the Conservation of Places of Cultural Significance ("Burra Charter"). Retrieved November 2014, from http://australia.icomos.org/wp-content/uploads/Burra-Charter_1979.pdf

ICOMOS Australia. (2013a). Burra Charter Practice Note: Understanding and assessing cultural significance. Retrieved January 26th, 2016, from http://australia.icomos.org/publications/charters/

ICOMOS Australia. (2013b). The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance, 2013. Retrieved November 2014, from http://australia.icomos.org/publications/charters/

ICOMOS Canada. (1983). The Appleton Charter for the Protection and Enhancement of the Built Environment. Retrieved October 7th 2011, from www.international.icomos.org/charters/appleton.pdf

ICOMOS New Zealand. (2010). Charter for the Conservation of Places of Cultural Heritage Value (ICOMOS New Zealand). Retrieved October 2011, from http://www.international.icomos.org/charters/ICOMOS_NZ_Charter_2010_FINAL_11_Oct_2010.pdf

IEC. (2009). IEC/ISO 31010:2009, *Risk management - risk assessment techniques*. Geneve: International Electrotechnical Commission.

Iglesias-Campos, M. Á. (2014). Effects of mechanical cleaning by manual brushing and abrasive blasting on lime render coatings on Architectural Heritage. *Materiales de Construcción, 64*(316), e039. doi:10.3989/mc.2014.08313

Iglesias-Campos, M. Á., García-Fortes, S. & Prada-Perez, J. L. (2014). Influence of projection angle in sandblasting cleaning on detrictic stone materials in Architectural Heritage. *Materiales de Construcción, 64*(314), e021. doi:10.3989/mc.2014.02113

Iglesias-Campos, M. Á., Prada-Perez, J. L. & García-Fortes, S. (2015). Microblasting cleaning for façade repair and maintenance: Selecting technical parameters for treatment efficiency. *Construction and Building Materials, 94*, 605-612. doi:10.1016/j.conbuildmat.2015.07.033

Iglesias, M., Gea, B., Prada, J. L. & Guasch, N. (2006, 21-24 June). *Low-pressure abrasive cleaning of historic building materials*. Paper presented at the International Conference on Heritage, Weathering and Conservation - HWC-2006. R. Fort, M. Alvarez de Buergo, M. Gomez-Heras & C. Vazquez-Calvo (Eds.), Vol. II, pp. 681-686. Madrid: Taylor & Francis.

Illescas, J. F. & Mosquera, M. J. (2011). Surfactant-synthesized PDMS/silica nanomaterials improve robustness and stain resistance of carbonate stone. *The Journal of Physical Chemistry C, 115*(30), 14624-14634. doi:10.1021/jp203524p

Illescas, J. F. & Mosquera, M. J. (2014, June 24-27). *Increasing surface roughness of coatings to promote high-hydrophobicity*. Paper presented at the Second International Congress on Science, Technology and Cultural Heritage. M. A. Rogerio-Candelera (Ed.), pp. 151-156. Seville: Taylor & Francis Group.

IPSN. (2000). Acceptability and safety objectives, use of concepts through various areas, *Final report prepared by IPSN for EU/ DG XXIV* (Vol. Contract N° B5-1030/99/094994). Fontenay-aux-Roses: Institut de Protection et de Sûreté Nucléaire.

Isebaert, A., Van Parys, L. & Cnudde, V. (2014). Composition and compatibility requirements of mineral repair mortars for stone–A review. *Construction and Building Materials, 59*, 39-50. doi:10.1016/j.conbuildmat.2014.02.020

ISO. (2009). ISO Guide 73/2009: Risk management vocabulary, *International Organization for Standardization*.

Jokilehto, J. (1986). *A History of Architectural Conservation: the Contribution of English, French, German and Italian thought towards an international approach to the conservation of cultural property.* PhD Dissertation, University of York, York.

Jokilehto, J. (1988). Conservation principles and their theoretical background. *Durability of Building Materials, 5*, 267-277.

Jokilehto, J. (1994). *Authenticity: a general framework for the concept.* Paper presented at the Nara Conference on Authenticity. K. E. Larsen (Ed.), pp. 17-34. Nara: UNESCO / Japanese Agency for Cultural Affairs / ICCROM / ICOMOS.

Jokilehto, J. (1999). *A History of Architectural Conservation*. Oxford: Butterworth-Heinemann.

Jokilehto, J. (2006). Considerations on authenticity and integrity in world heritage context. *City & Time, 2*(1), 1-16.

Jokilehto, J. (2007). An international perspective to conservation education. *Built Environment, 33*(3), 275-286.

Karlsson, B. & Larsson, D. (2000). *Using a Delphi panel for developing a fire risk index method for multistorey apartment buildings*. Lund: Lund University - Department of Fire Safety Engineering.

Karoglou, M., Bakolas, A., Kouloumbi, N. & Moropoulou, A. (2011). Reverse engineering methodology for studying historic buildings coatings: The case study of the Hellenic Parliament neoclassical building. *Progress in Organic Coatings, 72*(1), 202-209. doi:10.1016/j.porgcoat.2011.01.008

Kerr, J. S. (2013). The Seventh Edition Conservation Plan, A Guide to the Preparation of Conservation Plans for Places of European Cultural Significance. Sydney: The National Trust of Australia (NSW). Available from http://australia.icomos.org/wp-content/uploads/The-Conservation-Plan-7th-Edition.pdf

Kirby Talley Jr., M. (1999). The Delta Plan: a nationwide rescue operation. *Museum International, 51*(1), 11-15.

Klamer, A. & Zuidhof, P.-W. (1998, 1999). *The values of cultural heritage: merging economic and cultural appraisals.* Paper presented at the Economics and Heritage Conservation - Report of a Meeting Organized by the Getty Conservation Institute. M. d. l. Torre & R. Mason (Eds.). Los Angeles: The Getty Conservation Institute.

Klisińska-Kopacz, A., Tišlová, R., Adamski, G. & Kozłowski, R. (2008, 15-20 September 2008). *Control of the porosity structure to produce Roman cement mortars compatible with the historic substrate.* Paper presented at the 11th International Congress on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. II, pp. 931-937. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University Press.

Kuhfuss, L., Hanley, N. & Whyte, R. (2016). Should historic sites protection be targeted at the most famous? Evidence from a contingent valuation in Scotland. *Journal of Cultural Heritage*. doi:10.1016/j.culher.2016.01.004

Lanterna, G. & Matteini, M. (2000). Laser cleaning of stone artefacts: a substitute or alternative method? *Journal of Cultural Heritage, 1*, S29-S35.

Larsson, D. (2000). *Developing the Structure of a Fire Risk Index Method for Timber-frame Multistorey Apartment Buildings*. Lund: Lund University - Department of Fire Safety Engineering.

Lattig, J. W. (2012). *Calamities, catastrophes, and cataclysms: current trends in international disaster risk management practices for cultural heritage sites.* Masters Dissertation, University of Pennsylvania, Philadelphia, PA.

Laurenzi Tabasso, M. & Mecchi, A. M. (1985, 25-27 September). *Proposal for a methodology to evaluate the possible damage produced in stones by chemical cleanings.* Paper presented at the Vth International Congress on Deterioration and Conservation of Stone, Vol. 2, pp. 975-982. Lausanne: Presses Polytechniques Romandes.

Laurenzi Tabasso, M. & Simon, S. (2006). Testing methods and criteria for the selection/evaluation of products for the conservation of porous building materials. *Reviews in Conservation, 7*, 67-82.

Lavelle, S. (2009). *Assessing Significance for Historical Archaeological Sites and 'Relics'*. Heritage Council of NSW. Retrieved from http://www.environment.nsw.gov.au/resources/heritagebranch/heritage/ArchSignificance.pdf.

Lawrence, R. (2006). *A study of carbonation in non-hydraulic lime mortars.* PhD Dissertation, University of Bath, Bath.

Lazzarini, L. & Laurenzi Tabasso, M. (1986). *Il Restauro della Pietra*. Padova: CEDAM.
*Lei 107/2001 - Lei de Bases do Património Cultural*, Assembleia da República Portuguesa (2001).
Leveau, P. (2011). Restauration et traduction: une question de philosophie. *CeROArt. Conservation, exposition, Restauration d'Objets d'Art*. Retrieved from http://ceroart.revues.org/2088
Leveau, P. (2012). *Epistémologie de la conservation du patrimoine : ontologie d'un domaine, ergologie d'une discipline.* PhD Dissertation, Université d'Aix-Marseille, Marseille.
Lindqvist, J.-E., Malaga, K. & Middendorf, B. (2008, 15-20 September 2008). *Importance of micro- and macro-porosity on freeze-thaw behaviour of natural stones.* Paper presented at the 11th International Congress on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. I, pp. 693-700. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University Press.
Linstone, H. A. & Turoff, M. (2002). Introduction. In H. A. Linstone & M. Turoff (Eds.), *The Delphi Method - Techniques and Applications*. New Jersey: New Jersey Institute of Technology.
Lipe, W. D. (1984). Value and meaning in cultural resources. In H. Cleere (Ed.), *Approaches to the Archaeological Heritage: A Comparative Study of World Cultural Resource Management Systems* (pp. 1-11). Cambridge: Cambridge University Press.
Lobo de Carvalho, J. M. (2007). *Conservação do Património. Políticas de Sustentabilidade Económica [Heritage Conservation. Policies for Economic Sustainability]*. PhD Dissertation, Instituto Superior Técnico, Lisbon.
Lockwood, M. & Spennemann, D. H. R. (2001, 4 July 2000). *Value conflicts between natural and cultural heritage conservation - Australian experience and the contribution of economics.* Paper presented at the Heritage Economics: Challenges for heritage conservation and sustainable development in the 21st Century, pp. 216-241. Australian National University, Canberra: Australian Heritage Commission.
López-Arce, P., Gomez-Villalba, L. S., Pinho, L., Fernández-Valle, M. E., Álvarez de Buergo, M. & Fort, R. (2010). Influence of porosity and relative humidity on consolidation of dolostone with calcium hydroxide nanoparticles: effectiveness assessment with non-destructive techniques. *Materials Characterization, 61*(2), 168-184. doi:10.1016/j.matchar.2009.11.007
Lowenthal, D. (1999). Authenticity: Rock of Faith or Quicksand Quagmire? *The Getty Conservation Institute Newsletter, 14*(3). Retrieved from http://www.getty.edu/conservation/publications_resources/newsletters/14_3/feature1_2.html
Luger, T. (2011). *A new method for assessing the value of collections.* Paper presented at the ICOM-CC 16th Triennial Conference. J. Bridgland (Ed.). Lisbon: ICOM-CC (CD-ROM preprints).
Mack, R. C. & Grimmer, A. (2000). Assessing Cleaning and Water-Repellent Treatments for Historic Masonry Buildings, *Preservation Briefs 1*. Washington DC: U.S. Department of the Interior, National Park Service, Cultural Resources, Heritage Preservation Services.
MacLeod, I. D. & Car, R. J. (2014). Determining treatment priorities for ecclesiastical textiles using significance and conservation assessments. *Journal of Cultural Heritage, 15*(6), 628-636.
Malaga, K. & Bengtsson, T. (2008, 15–20 September 2008). *Full scale study on the performance of different cleaning agents on granite and limestone surfaces in urban environments.* Paper presented at the 11th International Conference on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. II, pp. 975-982. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University Press.
Mamillan, M. & Simonnet, J. (1972). Recherches des proprietes physiques, permettant de juger de l'efficacité d'un traitement sur les pierres alterées. In R. Rossi-Manaresi & G. Torraca (Eds.), *The Treatment of Stone - Proceedings of the Meeting of the Joint Committee for the Conservation of Stone* (pp. 201-230). Bologna: Centro per la Conservazione delle Sculture all'Aperto.
Mansoux, H. (2000). Acceptability and Safety Objectives, Use of Concepts Through Various Areas. Contract EU/DGXXIV n°B5-1030/99/094994. Note SEGR/LSEES 00-99: available at http://cryptome.org/0004/enviro-risk.pdf (assessed July 12th 2011).
Maravelaki, P., Biscontin, G., Polloni, R., Cecchetti, W. & Zendri, E. (1992, 15-18 June 1992). *Investigation on surface alteration of limestone related to cleaning processes.* Paper presented at the 7th International Congress on Deterioration and Conservation of Stone. J. Delgado Rodrigues, F. M. A. Henriques & F. T. Jeremias (Eds.), Vol. 3, pp. 1093-1102. Lisbon, Portugal: Laboratório Nacional de Engenharia Civil.
Mascalchi, M., Osticioli, I., Riminesi, C., Cuzman, O. A., Salvadori, B. & Siano, S. (2015). Preliminary investigation of combined laser and microwave treatment for stone biodeterioration. *Studies in Conservation, 60*(S1), S19-S27. doi:10.1179/0039363015Z.000000000203
Mason, R. (1998, 1999). *Economics and heritage conservation: concepts, values, and agendas for research.* Paper presented at the Economics and Heritage Conservation – Report of a Meeting

Organized by the Getty Conservation Institute. M. de la Torre & R. Mason (Eds.), pp. 2-18. Los Angeles: The Getty Conservation Institute.

Mason, R. (2002). Assessing values in conservation planning: methodological issues and choices. In M. d. l. Torre (Ed.), *Assessing the Values of Cultural Heritage* (pp. 5-30). Los Angeles: GCI.

Mason, R. (2004). Fixing Historic Preservation: a constructive critique of "Significance" [Research and Debate]. *Places, 16*(1), 66-71. Retrieved from http://eprints.cdlib.org/uc/item/74q0j4j2

Mason, R. (2006). Theoretical and practical arguments for values-centered preservation. *CRM: The Journal of Heritage Stewardship*(Summer 2006), 21-48.

Mason, R., Maclean, M. G. H. & de la Torre, M. (2003). *Hadrian's Wall World Heritage Site: a Case Study*. Los Angeles: The Getty Conservation Institute.

Matero, F. (2003). Exploring conservation strategies for ancestral puebloan sites: Tsankawi, Bandelier National Monument, New Mexico. *Conservation and Management of Archaeological Sites, 6*(2). Retrieved from http://repository.upenn.edu/hp_papers/13/?referer=sphere_search

Matteini, M., Moles, A., Oeter, M. & Tosini, I. (1995). Resine a scambio ionico nella pulitura dei manufatti lapidei e delle pitture murali: verifiche sperimentali e applicazioni. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 283-292). Padova: Libreria Progetto Editore.

Mazzanti, M. (2002). Cultural heritage as multi-dimensional, multi-value and multi-attribute economic good: toward a new framework for economic analysis and valuation. *The Journal of Socio-Economics, 31*(5), 529-558. doi:10.1016/S1053-5357(02)00133-6

Mecchi, A. M., Poli, T., Realini, M. & Sansonetti, A. (2008, 15–20 September 2008). *A proposal for a common approach in choosing tests for the protocol evaluation of cleaning methods.* Paper presented at the 11th International Conference on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. I, pp. 425-433. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University.

Meneses, U. T. B. d. (2009). *O campo do Patrimônio Cultural: uma revisão de premissas.* Paper presented at the Fórum Nacional do Patrimônio Cultural: Sistema Nacional de Patrimônio Cultural: desafios, estratégias e experiências para uma nova gestão, pp. 25-39. Ouro Preto/MG: IPHAN.

Michalski, S. (1992). *Sharing responsibility for conservation decisions.* Paper presented at the Dahlem Workshop on Durability and Change: the Science, Responsibility, and Cost of Sustaining Cultural Heritage. W. E. Krumbein, P. Brimblecombe, D. E. Cosgrove & S. Staniforth (Eds.), pp. 241-258. Dahlem: John Wiley & Sons.

Michalski, S. (2008, 22-26 September). *Social discount rate: modelling collection value to future generations, and understanding the difference between short-term and long-term preservation actions.* Paper presented at the ICOM-CC 15th Triennial Conference. J. Bridgland (Ed.), Vol. II, pp. 751-758. New Delhi.

Miliani, C., Velo-Simpson, M. L. & Scherer, G. W. (2007). Particle-modified consolidants: a study on the effect of particles on sol–gel properties and consolidation effectiveness. *Journal of Cultural Heritage, 8*(1), 1-6. doi:10.1016/j.culher.2006.10.002

Mohr, E. & Schmidt, J. (1997). Aspects of economic valuation of cultural heritage. In N. S. Baer & R. Snethlage (Eds.), *Saving our Architectural Heritage: the Conservation of Historic Stone Structures (Dahlem Workshop Report)* (pp. 333-348). Chichester: John Wiley & Sons Ltd.

Moncrieff, A. & Weaver, G. (1992). *Science for Conservators - Vol. 2: Cleaning*. J. Ashley-Smith (Ed.), (3rd ed.). Oxon: Routledge.

*Monumentenwet - Monuments and Historic Buildings Act*, The Netherlands Ministry of Education, Culture and Science (1988/2011).

Moreau, C., Leroux, L., Vergès-Belmin, V., Fronteau, G. & Barbin, V. (2008). *Which Factors Influence Most the Durability of Water Repellent Treatments: Stone Properties, Climate or Atmospheric Pollution?* Paper presented at the Hydrophobe V - 5th International Conference on Water Repellent Treatment of Building Materials, Vol. 5, pp. 129-142: Aedificatio Publishers.

Moreau, C., Vergès-Belmin, V., Leroux, L., Orial, G., Fronteau, G. & Barbin, V. (2008). Water-repellent and biocide treatments: assessment of the potential combinations. *Journal of Cultural Heritage, 9*(4), 394-400. doi:10.1016/j.culher.2008.02.002

Moropoulou, A. (2000a). Innovative education and training for the conservation of cultural heritage. In A. Moropoulou, G. Biscontin, J. Delgado Rodrigues, M. Erdik, M. Siotis & S. Zoppi (Eds.), *PACT 58 - Compatible Materials for the Protection of Cultural Heritage* (pp. 71-80). Athens: Technical Chamber of Greece; Conseil de l'Europe.

Moropoulou, A. (2000b). Reverse engineering to discover traditional technologies: a proper approach for compatible restoration mortars. In A. Moropoulou, G. Biscontin, J. Delgado Rodrigues, M.

Erdik, M. Siotis & S. Zoppi (Eds.), *PACT 58 - Compatible Materials for the Protection of Cultural Heritage* (pp. 81-107). Athens: Technical Chamber of Greece; Conseil de l'Europe.

Moropoulou, A., Bakolas, A., Moundoulas, P. & Aggelakopoulou, E. (2005). *Reverse engineering: a proper methodology for compatible restoration of mortars.* Paper presented at the International RILEM Workshop Repair Mortars for Historic Masonry. C. Groot (Ed.), pp. 278 - 291. Delft: RILEM.

Moropoulou, A., Delegou, E. T., Konstadinidou, M. & Kiranoudis, C. (2008, 11-14 May 2008). *Decision making about cleaning interventions on marble surfaces using a fuzzy logic approach.* Paper presented at the 11th International Conference on Durability of Building Materials and Components, pp. 1275-1285. Istanbul: Istanbul Technical University.

Moropoulou, A., Theoulakis, P., Tsiourva, T. & Haralampopoulos, G. (2000). Compatibility evaluation of consolidation treatments in monument scale. In A. Moropoulou, G. Biscontin, J. D. Rodrigues & M. Erdik (Eds.), *PACT 59 - Compatible Materials Recommendations for the Preservation of European Cultural Heritage* (pp. 209-230). Athens: Conseil de l'Europe; Association of Civil Engineers of Greece; Technical Chamber of Greece.

Morris, W. (1877). The Manifesto of the Society for the Protection of Ancient Buildings. Retrieved from www.spab.org.uk/what-is-spab-/the-manifesto

Mosquera, M. J., de los Santos, D. M. & Rivas, T. (2010). Surfactant-synthesized ormosils with application to stone restoration. *Langmuir, 26*(9), 6737-6745. doi:10.1021/la9040979

Muñoz-Viñas, S. (2005). *Contemporary Theory of Conservation*. Oxford: Elsevier Butterworth-Heinemann.

Muñoz-Viñas, S. (2015a). Praska Lecture: Pride and Prejudice and Patina [Video]. New York: The Institute of Fine Arts. Posted to https://vimeo.com/119253627

Muñoz-Viñas, S. (2015b). "Who is Afraid of Cesare Brandi?" Personal reflections on the Teoria del restauro. *CeROArt. Conservation, exposition, Restauration d'Objets d'Art*. Retrieved from http://ceroart.revues.org/4653

Nanda, R., Burke, F., Burman, P. A. T. I., Kohler, N., Miletti, D. S., Roemich, H., et al. (2001). Group report: Values and Society. In N. S. Baer & F. Snickars (Eds.), *Rational Decision-making in the Preservation of Cultural Property - Dahlem Workshop Report 86* (pp. 61-80). Berlin: Dahlem University Press.

Nijkamp, P. (1991). Evaluation measurement in conservation planning. *Journal of Cultural Economics, 15*(1), 1-27.

Nolan, D. & Ruane, P. (2004). *St Brendan's Cathedral, Clonfert, County Galway: conservation plan*. Dublin: Heritage Council of Ireland.

Noonan, D. S. (2003). Contingent valuation and cultural resources: a meta-analytic review of the literature. *Journal of Cultural Economics, 27*(3-4), 159-176. doi:10.1023/A:1026371110799

OED. *Valuation*. Oxford Dictionaries. Oxford: Oxford University Press.

Okoli, C. & Pawlowski, S. D. (2004). The Delphi method as a research tool: an example, design considerations and applications. *Inform. Manage., 42*, 15-29. doi:10.1016/j.im.2003.11.002

Olley, J., Mulvin, L., O'Daly, G. & Lewis, J. O. (1989, 13-16 June). *Architectural detail, weathering, and stone decay.* Paper presented at the Science, Technology and European Cultural Heritage. N. S. Baer, C. Sabbioni & A. I. Sors (Eds.), pp. 668-670. Bologna: Butterworth-Heinemann Publishers for the Commission of European Communities.

Ortiz, P., Antunez, V., Martín, J. M., Ortiz, R., Vázquez, M. A. & Galán, E. (2014). Approach to environmental risk analysis for the main monuments in a historical city. *J. Cult. Herit., 15*, 432-440. doi:10.1016/j.culher.2013.07.009

Ottosen, L. M., Skibsted, G. & Præstholm, T. (2014). *Electrodesalination of sandstones with irregular shapes and uneven salt distribution.* Paper presented at the SWBSS 2014 - Third International Conference on Salt Weathering of Buildings and Stone Sculptures. H. De Clercq (Ed.), pp. 405-420. Brussels: Koninkljik Instituut voor het Kunstpatrimonium (KIK) - Institut Royal du Patrimoine Artistique (IRPA).

Papayianni, I. (1998). Criteria and methodology for manufacturing compatible repair mortars and bricks. In G. Biscontin, A. Moropoulou, M. Erdik & J. Delgado Rodrigues (Eds.), *PACT 56 - Compatible Materials for the Protection of Cultural Heritage* (pp. 179-190). Athens: Technical Chamber of Greece; Conseil de l'Europe.

Pavia Santamaria, S., O'Brien, P. & Cooper, T. P. (1996). Evaluation of cleaning methods for granite based on petrographic examinations. *Materials and Structures/Matériaux et Constructions, 29*(3), 185-189.

Pinna, D. (1995). La pulitura e il controllo della crescita biologica sui materiali lapidei. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 619-624). Padova: Libreria Progetto Editore.

*Planning (Listed Buildings and Conservation Areas) Act 1990*, Parliament of the United Kingdom (1990).

PMI. (2016). What is Project Management? Retrieved March 2016, from http://www.pmi.org/en/About-Us/About-Us-What-is-Project-Management.aspx

Pouli, P., Fotakis, C., Hermosin, B., Saiz-Jimenez, C., Domingo, C., Oujja, M., et al. (2008). The laser-induced discoloration of stonework; a comparative study on its origins and remedies. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 71*, 932–945. doi:10.1016/j.saa.2008.02.031

Pouli, P., Oujja, M. & Castillejo, M. (2012). Practical issues in laser cleaning of stone and painted artefacts: optimisation procedures and side effects. *Applied Physics A, 106*(2), 447-464. doi:10.1007/s00339-011-6696-2

Poulios, I. (2010). Moving beyond a values-based approach to heritage conservation. *Conservation and Management of Archaeological Sites, 12*(2), 170-185. doi:10.1179/175355210X12792909186539

Poulios, I. (2014). *Past in the Present: A Living Heritage Approach - Meteora, Greece*. London: Ubiquity Press.

Pozo, S., Barreiro, P., Rivas, T., González, P. & Fiorucci, M. P. (2014). Effectiveness and harmful effects of removal sulphated black crust from granite using Nd:YAG nanosecond pulsed laser. *Applied Surface Science, 302*, 309-313. doi:10.1016/j.apsusc.2013.10.129

Prieto, B., Ferrer, P., Sanmartín, P., Cárdenes, V. & Silva, B. (2011). Color characterization of roofing slates from the Iberian Peninsula for restoration purposes. *Journal of Cultural Heritage, 12*, 420-430. doi:10.1016/j.culher.2011.02.001

PRODOMEA. (2004). *First Annual Report - Covering period from 1st January 2003 to 31st December 2003* (Deliverable No. 01): INCO: International Scientific Cooperation Projects (1998-2002) Contract No ICA3-CT-2002-10021.

PRODOMEA. (n.d.). PRODOMEA. Retrieved March 5th 2012, from www.prodomea.com

Quaresima, R., Di Giuseppe, E. & Volpe, R. (1995). Impiego di biocidi per la rimozione della microflora algale. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 267-275). Padova: Libreria Progetto Editore.

RCE. (2014). *Assessing Museum Collections - Collection Valuation in Six Steps*. Rijksdienst voor het Cultureel Erfgoed. Retrieved from http://cultureelerfgoed.nl/sites/default/files/publications/assessing-museum-collections.pdf.

Revez, M. J. & Delgado Rodrigues, J. (2016). Incompatibility risk assessment procedure for the cleaning of built heritage. *Journal of Cultural Heritage, 18*, 219–228. doi:10.1016/j.culher.2015.09.003

Revez, M. J., Raposo, M. & Delgado Rodrigues, J. (2012). *The PRODOMEA phasing and compatibility indicators as tools for the planning and design of conservation interventions. Assessment and validation in the Santa Clara-a-Velha Monastery (Coimbra, Portugal)*. Poster presented at the 12th International Congress on Deterioration and Conservation of Stone, Columbia University, New York. Retrieved from http://iscs.icomos.org/cong-12.html

Richmond, A. & Bracker, A. (2009). Introduction. In A. Richmond & A. Bracker (Eds.), *Conservation: Principles, Dilemmas and Uncomfortable Truths* (pp. xiv-xviii). London: Butterworth-Heinemann in association with the V&A Museum.

Riegl, A. (1982). The modern cult of monuments: its character and its origin. [Kurt. W. Forster and Diane Ghirardo, Trans.]. *Oppositions*(25), 20-51.

Riegl, A. (1984). *Le Culte Moderne des Monuments: Son Essence et Sa Genèse* (D. Wieczorek, Trans.). Paris: Éditions du Seuil.

Riegl, A. (1996). Readings from "The Modern Cult of Monuments: Its Essence and Its Development" (K. Bruckner & K. Williams, Trans.). In N. S. Price, J. M.K. Talley & A. M. Vaccaro (Eds.), *Historical and Philosophical Issues in the Conservation of Cultural Heritage* (pp. 69-83). Los Angeles: The Getty Conservation Institute.

Riganti, P. (2006). *Tourists' satisfaction vs. residents' quality of life in medium sized European cities: a conjoint analysis approach for cultural tourism's impact assessment*. Paper presented at the ERSA 2006 - 46th Congress of the European Regional Science Association: "Enlargement, Southern Europe and the Mediterranean". Volos, Greece. Retrieved from http://www-sre.wu-wien.ac.at/ersa/ersaconfs/ersa06/papers/678.pdf

Riganti, P. & Nijkamp, P. (2004, 25-29 August). *Valuing cultural heritage benefits to urban and regional development.* Paper presented at the 44th European Congress of the European Regional Science Association Regions and Fiscal Federalism. Universidade do Porto, Oporto.

Riganti, P. & Nijkamp, P. (2005, 23-27 August). *Benefit transfers of cultural heritage values: how far can we go? (Draft).* Paper presented at the Land Use and Water Management in a Sustainable Network Society - 45th Congress of the European Regional Science Association. Vrije Universiteit Amsterdam.

Rodriguez-Navarro, C., Elert, K., Sebastian, E., Esbert, R. M., Grossi, C. M., Rojo, A., et al. (2003). Laser cleaning of stone materials: an overview of current research. *Studies in Conservation, 48*(Supplement-1), 65-82.

Rossi Manaresi, R. (1977). Alterazione delle pietre e interventi conservativi sui monumenti. *Inarcos, 383*, 418-439.

Roudet, L. (2007). *L'Intervention minimale en conservation-restauration des biens culturels: exploration d'une notion.* MA Dissertation, Université Paris I Panthéon-Sorbonne, Paris.

Ruijgrok, E. C. M. (2006). The three economic values of cultural heritage: a case study in the Netherlands. *Journal of Cultural Heritage, 7*(3), 206-213. doi:10.1016/j.culher.2006.07.002

Russell, R. & Winkworth, K. (2009). Significance 2.0: A Guide to Assessing the Significance of Collections. Retrieved July 2015, from http://arts.gov.au/resources-publications/industry-reports/significance-20

Sage, A. P. (1998, 11-14 October). *Risk management for sustainable development.* Paper presented at the IEEE International Conference on Systems, Man, and Cybernetics, Vol. 5, pp. 4815-4819. San Diego, CA: IEEE.

Salvadori, O. & Charola, A. E. (2011). Methods to prevent biocolonization and recolonization: an overview of current research for architectural and archaeological heritage. In A. E. Charola, C. McNamara & R. J. Koestler (Eds.), *Biocolonization of Stone: Control and Preventive Methods - Proceedings from the MCI Workshop Series* (Vol. 2, pp. 37-50). Washington D.C.: Smithsonian Institution Scholarly Press.

Sanmartín, P., Cappitelli, F. & Mitchell, R. (2014). Current methods of graffiti removal: A review. *Construction and Building Materials, 71*, 363-374. doi:10.1016/j.conbuildmat.2014.08.093

Sanna, U., Atzeni, C. & Spanu, N. (2008). A fuzzy number ranking in project selection for cultural heritage sites. *Journal of Cultural Heritage, 9*, 311-316. doi:10.1016/j.culher.20070.12.004

Sasse, H. R. & Snethlage, R. (1996). Evaluation of stone consolidation treatments. *Science and Technology for Cultural Heritage, 5*(1), 85-92.

Sasse, H. R. & Snethlage, R. (1997). Methods for evaluation of stone conservation treatments. In N. S. Baer & R. Snethlage (Eds.), *Saving our Architectural Heritage: the Conservation of Historic Stone Structures (Dahlem Workshop Report)* (pp. 223-243). Chichester: John Wiley & Sons Ltd.

Schueremans, L., Cizer, Ö., Janssens, E., Serré, G. & Van Balen, K. (2011). Characterization of repair mortars for the assessment of their compatibility in restoration projects: Research and practice. *Construction and Building Materials, 25*, 4338-4350. doi:10.1016/j.conbuildmat.2011.01.008

Siano, S., Agresti, J., Cacciari, I., Ciofini, D., Mascalchi, M., Osticioli, I., et al. (2012). Laser cleaning in conservation of stone, metal, and painted artifacts: state of the art and new insights on the use of the Nd:YAG lasers. *Applied Physics A, 106*, 419-446. doi:10.1007/s00339-011-6690-8

Siano, S., Fabiani, F., Pini, R., Salimbeni, R., Giamello, M. & Sabatini, G. (2000). Determination of damage thresholds to prevent side effects in laser cleaning of pliocene sandstone of Siena. *Journal of Cultural Heritage, 1*, S47-S53.

Silva, B. A., Ferreira Pinto, A. P. & Gomes, A. (2014). Influence of natural hydraulic lime content on the properties of aerial lime-based mortars. *Construction and Building Materials 72* 208-218. doi:10.1016/j.conbuildmat.2014.09.010

Silva, B. A., Ferreira Pinto, A. P. & Gomes, A. (2015). Natural hydraulic lime versus cement for blended lime mortars for restoration works. *Construction and Building Materials, 94*, 346-360. doi:10.1016/j.conbuildmat.2015.06.058

Skoulikidis, T., Papakonstantinou, P. & Charalambous, D. (1976). *Restauration d'anciens objets d'art en marbre détériorés: inversion de la sulfatation-utilisation de* $CaSO_4.2H_2O$ *et transformation en* $CaCO_3$. Paper presented at the Second International Symposium on the Deterioration of Building Stones. V. Romanovsky (Ed.), pp. 171-178. Athens: National Technical University.

Slaton, D. & Normandin, K. C. (2005). Masonry cleaning technologies: overview of current practice and techniques. *Journal of Architectural Conservation, 11*(3), 7-31. doi:10.1080/13556207.2005.10784950

Smars, P. (1998, December 11th-12th). *Some reflections on the application of the concept of compatibility to Heritage.* Paper presented at the Initiative for Promoting the Use of Compatible Materials in the Protection of European Cultural Heritage from Environmental Risks. Athens.

Smars, P., Seif, A. & Santana, M. (2012, 31 October). *Defining the Structural Risk at the Archaeological Site of Baalbek.* Paper presented at the Tangible Risks, Intangible Opportunities: Long-term Risk Preparedness and Responses for Threats to Cultural Heritage ICOMOS Scientific Symposium, pp. 115-124. Beijing: ICOMOS China.

Smith, L. (2006). *Uses of Heritage*. Oxon: Routledge.

Snethlage, R. & Sterflinger, K. (2011). Stone conservation. In S. Siegesmund & R. Snethlage (Eds.), *Stone in Architecture: Properties, Durability* (4th ed., pp. 411-544). Berlin-Heidelberg: Springer.

Stambolov, T. (1968). Notes on the removal of iron stains from calcareous stone. *Studies in Conservation, 13*(1), 45-47.

Stambolov, T. (1971, 1972). *Cleaning and conservation of stone objects.* Paper presented at the The Treatment of Stone - Meeting of the Joint Committee for the Conservation of Stone. R. Rossi-Manaresi & G. Torraca (Eds.), pp. 65-71. Bologna: Centro per la Conservazione delle Sculture all'Aperto.

Stevens, T. H., Belkner, R., Dennis, D., Kittredge, D. & Willis, C. (2000). Comparison of contingent valuation and conjoint analysis in ecosystem management. *Ecological Economics, 32*, 63–74.

Stoeglehner, G., Brown, A. L. & Kørnøv, L. B. (2009). SEA and planning:'ownership'of strategic environmental assessment by the planners is the key to its effectiveness. *Impact assessment and project appraisal, 27*(2), 111-120. doi:10.3152/146155109X438742

Stovel, H. (1998). *Risk Preparedness: a Management Manual for World Cultural Heritage*. Rome: ICCROM.

Stubbs, J. H. (2009). *Time Honored: A Global View of Architectural Conservation: Parameters, Theory & Evolution of an Ethos*. New Jersey: John Wiley & Sons, Inc.

Sujarwo, W. & Caneva, G. (2016). Using quantitative indices to evaluate the cultural importance of food and nutraceutical plants: Comparative data from the Island of Bali (Indonesia). *Journal of Cultural Heritage, 18*, 342-348. doi:10.1016/j.culher.2015.06.006

Taylor, J. & Cassar, M. (2008). *Representation and intervention: the symbiotic relationship of conservation and value.* Paper presented at the Conservation and Access: Contributions to the London Congress. D. Saunders, J. H. Townsend & S. Woodcock (Eds.), pp. 7-11. London: IIC (International Institute for Conservation of Historic and Artistic Works).

Teutonico, J. M., Charola, A. E., De Witte, E., Grassegger, G., Koestler, R. J., Laurenzi Tabasso, M., et al. (1997). Group report: How can we ensure the responsible and effective use of treatments (cleaning, consolidation, protection). In N. S. Baer & R. Snethlage (Eds.), *Saving Our Architectural Heritage: the Conservation of Historic Stone Structures (Dahlem Workshop Report)* (pp. 293-313). Chichester: John Wiley & Sons, Ltd.

Thaheem, M. J. (2014). *Project Risk Management for sustainable restoration of immovable cultural heritage: lessons from construction industry and formulation of a customized PRM model.* PhD Dissertation, Politecnico di Torino, Turin.

Thorn, A. (1993, 22-27 August). *The impact of disodium EDTA on stone.* Paper presented at the ICOM Committee for Conservation 10th Triennial Meeting, Vol. 1, pp. 357-363. Washington, DC: International Council of Museums Committee for Conservation.

Thorn, A. (2005, 12-16 September). *Treatment of heavily iron-stained limestone and marble sculpture.* Paper presented at the ICOM Committee for Conservation 14th Triennial Meeting, pp. 888-894. The Hague: James & James.

Throsby, D. (1995). Culture, economics and sustainability. *Journal of Cultural Economics, 19*(3), 199-206. doi:10.1007/BF01074049

Throsby, D. (2003). Determining the value of cultural goods: How much (or how little) does contingent valuation tell us? *Journal of Cultural Economics, 27*(3), 275-285.

Toniolo, L., Cappitelli, F., Sorlini, C. & Gulotta, D. (2008, 15–20 September). *The biological approach for the removal of black crusts from stone surface of historical monuments.* Paper presented at the 11th International Congress on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. II, pp. 1077-1084. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University.

Toniolo, L., Paradisi, A., Goidanich, S. & Pennati, G. (2011). Mechanical behaviour of lime based mortars after surface consolidation. *Construction and Building Materials, 25*(4), 1553-1559. doi:10.1016/j.conbuildmat.2010.08.010

Torgerson, D. J. & Raftery, J. (1999). Discounting. *British Medical Journal, 319*(7214), 914-915.

Torney, C., Forster, A. M. & Szadurski, E. M. (2014). Specialist ‘restoration mortars’ for stone elements: a comparison of the physical properties of two stone repair materials. *Heritage Science, 2*(1), 1. doi:10.1186/2050-7445-2-1

Torraca, G. (1995). La pulitura delle facciate in pietra: necessità della conservazione e immagine del monumento. In G. Biscontin & G. Driussi (Eds.), *La Pulitura delle Superfici dell'Architettura: Atti del Convegno di Studi, Bressanone, 3-6 luglio 1995* (Vol. XI, pp. 1-7). Padova: Libreria Progetto Editore.

Tourkolias, C., Skiada, T., Mirasgedis, S. & Diakoulaki, D. (2015). Application of the travel cost method for the valuation of the Poseidon temple in Sounio, Greece. *Journal of Cultural Heritage, 16*(4), 567-574. doi:10.1016/j.culher.2014.09.011

Tuan, T. H. & Navrud, S. (2008). Capturing the benefits of preserving cultural Heritage. *Journal of Cultural Heritage, 9*, 326-337.

Tuan, T. H., Seenprachawong, U. & Navrud, S. (2009). Comparing cultural heritage values in South East Asia–Possibilities and difficulties in cross-country transfers of economic values. *Journal of Cultural Heritage, 10*(1), 9-21.

Tuduce-Trăistaru, A. A., Campean, M. & Timar, M. C. (2010). Compatibility indicators in developing consolidation materials with nanoparticle insertions for old wooden objects. *International Journal of Conservation Science, 1*(4), 219-226.

Tulliani, J.-M., Formia, A. & Sangermano, M. (2011). Organic-inorganic material for the consolidation of plaster. *Journal of Cultural Heritage, 12*(4), 364-371. doi:10.1016/j.culher.2011.04.001

UNDRO. (1979). *Natural Disasters and Vulnerability Analysis - Report of Expert Group Meeting (9-12 July 1979)*. United Nations Disaster Relief Organization. Retrieved from https://archive.org/details/naturaldisasters00offi.

UNESCO. (2003). Convention for the Safeguarding of the Intangible Cultural Heritage. Retrieved March 24th 2015, from http://www.unesco.org/culture/ich/en/convention

UNESCO. (2010). Managing Disaster Risks for World Heritage - World Heritage Resource Manual. Retrieved November 2015, from http://whc.unesco.org/document/104522

UNESCO. (2015). *Operational Guidelines for the Implementation of the World Heritage Convention*. Paris: UNESCO - World Heritage Centre.

UNESCO & ICOMOS. (1994). The Nara Document on Authenticity (Nara Conference on Authenticity in Relation to the World Heritage Convention). Retrieved October 2008, from http://www.international.icomos.org/charters/nara_e.htm

UNI. (2006). 11187:2006 - Beni culturali - Materiali lapidei naturali ed artificiali - Pulitura con tecnologia laser. Milan: UNI - Ente Nazionale Italiano di Unificazione.

Urquhart, D. C., Young, M. M. E. & Cameron, S. (1997). *Technical Advice Note 9: Stonecleaning of granite buildings*. Edinburgh: Historic Scotland.

V&AMCD. (2004). Victoria and Albert Museum Conservation Department Ethics Checklist Background Document. Retrieved January 2013: www.vam.ac.uk/res_cons/conservation/advice/policies/index.html

Valentini, F., Diamanti, A., Carbone, M., Bauer, E. M. & Palleschi, G. (2012). New cleaning strategies based on carbon nanomaterials applied to the deteriorated marble surfaces: A comparative study with enzyme based treatments. *Applied Surface Science, 258*(16), 5965-5980.

Van Balen, K. (2008). The Nara grid: an evaluation scheme based on the Nara document on authenticity. *APT bulletin, 49*(2-3), 39-45.

Van Balen, K., Papayianni, I., Van Hees, R., Binda, L. & Waldum, A. (2005). Introduction to Requirements for and Functions and Properties of Repair Mortars. *Materials and Structures, 38*, 781-785. Retrieved from http://www.rilem.net/images/publis/rep028-008.pdf. doi:10.1617/14319

van de Vall, R. (1999). *Painful decisions: Philosophical considerations on a decision-making model.* Paper presented at the Modern Art: Who Cares? Interdisciplinary Research Project and International Symposium on the Conservation of Modern and Contemporary Art. I. J. Hummelen & D. Sillé (Eds.), pp. 196-200. Amsterdam: The Foundation for the Conservation of Modern Art/Netherlands Institute for Cultural Heritage.

Van Den Eynde, V. C., Mateos, F. J. & Paradelo, R. (2013). Degradability of building stone: influence of the porous network on the rate of dissolution of carbonate and evaporitic rocks. *Journal of Cultural Heritage, 14*(2), 89-96. doi:10.1016/j.culher.2012.05.003

Vecco, M. (2010). A definition of cultural heritage: From the tangible to the intangible. *Journal of Cultural Heritage, 11*(3), 321-324. doi:10.1016/j.culher.2010.01.006

Veiga, M. R., Tavares, M. L. & Menezes, M. (2011). *Strategies for conservation of historical renderings. Factors and decision criteria.* Paper presented at the 16th ICOM Committee for Conservation Triennial Meeting. J. Bridgland (Ed.). Lisbon

Veiga, R. (2007). *Conservação e Reparação de Revestimentos de Paredes de Edifícios Antigos - Programa de Investigação e Programa de Pós-graduação apresentados para a obtenção do título de Habilitação para o Exercício de Funções de Coordenação de Investigação Científica*. Lisboa: LNEC.

Veiga, R., Fragata, A., Velosa, A. L., Magalhães, A. C. & Margalha, G. (2010). Lime-Based Mortars: Viability for Use as Substitution Renders in Historical Buildings. *International Journal of Architectural Heritage: Conservation, Analysis, and Restoration, 4*(2), 177-195. doi:10.1080/15583050902914678

Vella, D., Hadj Amar, A. B. & Chetcuti, F. (2008). *A preliminary investigation of the removal of rust stains from Globigerina limestone surfaces using coupled chelating-reducing systems* Paper presented at the 11th International Conference on Deterioration and Conservation of Stone. J. W. Łukaszewicz & P. Niemcewicz (Eds.), Vol. II, pp. 1093-1100. Nicolaus Copernicus University, Toruń: Nicolaus Copernicus University Press.

Verbeeck-Boutin, M. (2009). De l'axiologie. Pour une théorie des valeurs appliquée à la conservation-restauration. *CeROArt. Conservation, exposition, Restauration d'Objets d'Art [online],* (4). Retrieved from http://ceroart.revues.org/1298

Verganelaki, A., Kilikoglou, V., Karatasios, I. & Maravelaki-Kalaitzaki, P. (2014). A biomimetic approach to strengthen and protect construction materials with a novel calcium-oxalate–silica nanocomposite. *Construction and Building Materials, 62*, 8-17. doi:10.1016/j.conbuildmat.2014.01.079

Vergès-Belmin, V. (1996). Towards a definition of common evaluation criteria for the cleaning of porous building materials: a review. *Sci. Technol. Cult. Herit, 5*, 69-83.

Vergès-Belmin, V. & Dignard, C. (2003). Laser yellowing: myth or reality? *Journal of Cultural Heritage, 4*, 238s-244s.

Vergès-Belmin, V. & Labouré, M. (2005, 2007). *Poultices as a way to eliminate the yellowing effect linked to limestone laser cleaning.* Paper presented at the Lasers in the Conservation of Artworks: LACONA VI. J. Nimmrichter, W. Kautek & M. Schreiner (Eds.), Vol. Proceedings in Physics 116, pp. 115-124. Vienna, Austria: Springer.

Vergès-Belmin, V. & Siedel, H. (2005). Desalination of Masonries and Monumental Sculptures by Poulticing: A Review. *Restoration of Buildings and Monuments - Bauinstandsetzen und Baudenkmalpflege, 11*(6), 391–408.

Vicini, S., Gaggero, L. & Princi, E. (2013). Characterization, weathering, and protection of sandstones: The case of 'Agro d'Ardesia'. *Studies in Conservation, 58*(1), 50-57. doi:10.1179/2047058412Y.0000000066

Viles, H. (2005). Can stone decay be chaotic? In A. V. Turkington (Ed.), *Stone Decay in the Architectural Environment: GSA Special Paper 390* (pp. 11-16): Geological Society of America.

Villegas Sánchez, R. (2003). Metodología para la evaluación y estudio previo de tratamientos. In R. Villegas Sánchez & E. Sebastián Pardo (Eds.), *PH Cuadernos Técnicos: Metodología de diagnóstico y evaluación de tratamientos para la conservación de los edificios históricos* (Vol. 8, pp. 194-207). Seville: Junta de Andalucía - Consejería de Cultura - Instituto Andaluz del Patrimonio Histórico y Editorial Comares.

Villegas Sánchez, R., Sameño, M. & Baglioni, R. (2003). Tipología de Materiales para Tratamiento. In R. Villegas Sánchez & E. Sebastián Pardo (Eds.), *PH Cuadernos Técnicos: Metodología de Diagnóstico y la Evaluación de Tratamientos para la Conservación de los Edificios Históricos* (Vol. 8, pp. 168-193). Seville: Junta de Andalucía - Consejería de Cultura - Instituto Andaluz del Patrimonio Histórico y Editorial Comares.

Villers, C. (2004). Post minimal intervention. *The Conservator, 28*, 3-10.

Waller, R. (1994). *Conservation risk assessment: a strategy for managing resources for preventive conservation.* Paper presented at the Preventive Conservation Practice, Theory and Research. R. Ashok & P. Smith (Eds.), pp. 12-16. London: The International Institute for Conservation of Historic and Artistic Works.

Waller, R. (1996). Preventive conservation planning for large and diverse collections. In A. I. f. Conservation (Ed.), *Presession Preprints*.

Waller, R. & Michalski, S. (2004). Effective preservation: from reaction to prevention. *Getty Conservation Institute Newsletter, 19*(1), 4-9.

Watts, J. & Kaplan, M. (1998). *Development of a Prototypical Historic Fire Risk Index to Evaluate Fire Safety in Historic Buildings*. Washington DC: US Department of the Interior National Park Service, National Centre for Preservation Technology and Training.

Weaver, M. E. (1995). Removing graffiti from historic masonry, *Preservation Brief 38*. Washington D.C.: US Department of the Interior, National Park Service, Cultural Resources, Preservation Assistance.

Webster, R. G. M., Andrew, C. A., Baxter, S., MacDonald, J., Rocha, M., Thomson, B. W., et al. (1991). *Stonecleaning in Scotland: Research Summary*. Aberdeen: Historic Scotland, Scottish Enterprise and The Robert Gordon Institute of Technology.

Wells, J. C. (2010, March 22-27). *Valuing historic places: traditional and contemporary approaches.* Paper presented at the Preservation and Rehabilitation of Iraqi City Centers. Baghdad: School of Architecture, Art, and Historic Preservation Faculty Publications.

Wells, J. C. (n.d.). Historical Significance through the Lens of Contemporary Social, Cultural, and Experiential Values. Retrieved March 2016, from http://heritagestudies.org/files/Wells%20-%20Contemporary%20Values%20in%20HP.pdf

Werner, M. (1989, 13-16 June). *Research on cleaning methods applied to historical stone monuments.* Paper presented at the Science, Technology and European Cultural Heritage Symposium. N. S. Baer, C. Sabbioni & A. I. Sors (Eds.), pp. 688-691. Bologna: Butterworth-Heinemann Publishers for the Commission of European Communities.

Wheeler, G. E., Dinsmore, J. K., Ransick, L. J., Charola, A. E. & Koestler, R. J. (1984). Treatment of the Abydos reliefs: consolidation and cleaning. *Studies in Conservation, 29*(1), 42-48.

Xu, F., Li, D., Zhang, H. & Peng, W. (2012). TEOS/HDTMS inorganic–organic hybrid compound used for stone protection. *Journal of Sol-Gel Science and Technology, 61*(2), 429-435. doi:10.1007/s10971-011-2643-0

Xu, F., Wang, C., Li, D., Wang, M., Xu, F. & Deng, X. (2015). Preparation of modified epoxy–SiO 2 hybrid materials and their application in the stone protection. *Progress in Organic Coatings, 81*, 58-65. doi:10.1016/j.porgcoat.2014.12.017

Yin, R. (2003). *Case Study Research: Design and Methods* (3rd ed.). Thousand Oaks: Sage Publications.

Young, M., Ball, J. & Laing, R. A. (2000, 19-24th June). *Quantification of the long-term effects of stonecleaning on decay of building sandstones.* Paper presented at the 9th International Conference on Deterioration and Conservation of Stone. V. Fassina (Ed.), Vol. 2, pp. 179-186. Venice: Elsevier.

Zacharopoulou, G. (1998). The renascence of lime based mortar technology – an appraisal of a bibliographic study. In G. Biscontin, A. Moropoulou, M. Erdik & J. Delgado Rodrigues (Eds.), *PACT 55 - Compatible Materials for the Protection of European Cultural Heritage* (pp. 89-114). Athens: Technical Chamber of Greece; Conseil de l'Europe.

Zacharopoulou, G. (2011, October 7-8). *Creating potentials for standardization in historic masonries restoration.* Paper presented at the 8th International Conference Standardization, Prototypes and Quality: a Means of Balkan Countries' Collaboration, pp. 133-144. Thessaloniki.

Zafiropulos, V., Balas, C., Manousaki, A., Marakis, Y., Maravelaki-Kalaitzaki, P., Melesanaki, K., et al. (2003). Yellowing effect and discoloration of pigments: experimental and theoretical studies. *Journal of Cultural Heritage, 4*, 249-256.

Zancheti, S. M., Hidaka, L. T. F., Ribeiro, C. & Aguiar, B. (2009). Judgement and validation in the Burra Charter Process: Introducing feedback in assessing the cultural significance of heritage sites. *City & time, 4*(2), 47-53. Retrieved from http://www.ceci-br.org/novo/revista/docs2009/CT-2009-146.pdf

# Appendix A: Heritage Value Systems

**Table A.0.1:** Systems for the assessment of heritage values
(N.B.: chronological order; except where otherwise indicated, author citations were taken from their respective works as referenced in the first column).

| Author | Values/Criteria | Definitions |
|---|---|---|
| C. Boito (2000) (original edition: 1893) | Boito proposes that the conservation of architectural heritage be divided in three groups, according to the prevailing object feature: “archaeological importance” would call for an *archaeological conservation*, typically destined for Antiquity sites; the “picturesque aspect” would demand a *picturesque conservation*, generally suited for mediaeval buildings; “architectural beauty” prevailing would require an *architectural conservation*, which Boito found the most adequate for objects dating from the Renaissance onwards (2000: 34).<br>In defining building typologies, and in differentiating the conservation precepts that should be applied to each type of building, Boito indicates that there are distinct dominant values in each case, and that these should preside over conservation decisions. Even so, and dominant values notwithstanding, “one must keep an exact balance between the demands of archaeologie and of the picturesque, of statics and of aesthetics. However, such a balance is often found to be impossible to honour. One must make choices: lean towards one side or lean towards the other.” (2000: 37) | |
| | **Archaeological importance** | In objects of ‘archaeological importance’, essentially from Ancient Greek, Etruscan or Roman origin, every fragment is considered to have an “intrinsic importance” (2000: 34) as a document allowing for the study of the techniques and original building configuration. Boito recommends the exhaustive analysis of all the elements and, in cases where there is reliable information, that the object be restored by anastylosis, providing that missing structural elements are added in materials or techniques different from the original ones, and executed in broad lines, i.e., without decoration. |
| | **Picturesque aspect** | Picturesque conservation, in turn, would be applicable to buildings from the Middle Ages and correspond to structural reinforcements where necessary, “leaving the skin untouched, with its flesh and muscles: the skin tanned by the sun, wrinkled by the weather, broken here and there, full of scars, and still more appealing than the soft […] skin of a beautiful lady” (2000: 36), with the help of chemistry for the mitigation of degradation agents such as salts or for consolidation treatments, where necessary. |

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| | **Architectural beauty** | For the more recent buildings, i.e. those built from the Rennaissance onwards, in which "the organic unit has remained untouched" (2000: 38), the historic and documental value of individually considered elements become overshadowed by the importance of an aesthetical integrity, and thus their conservation allows not for renovations but for the use of similar materials and techniques that complete the missing parts, provided that they are discernible upon close inspection. |
| A.Riegl (1984) (1996) (original edition: 1903) | **<u>Remembrance values</u>** – exclusive of heritage objects: | |
| | **- age** | 'Vaguely aesthetic' (see note) component recognizable in every monument that evidences signs of weathering – imperfection, a lack of completeness, a tendency to dissolve shape and colour, [...] in complete contrast with [...] newly created works" (1996: 73). Riegl considered age value not only to be of relevance for the majority of the monuments, but also to be "the most modern one and the one that will prevail in the future" (1996: 72), highlighting its appealing to the popular opinion, rather than being perceived only by intellectual elites. As Jokilehto has put it, "this [age] value was the result of the modern awareness of time, and the desire to link one's existence with the historical time line" (1994: 29).<br>N.B.: According to Choay, the "age value [as defined by Riegl] occupies the social space traditionally dominated by religion" (Choay 2000a: 141) – and thus the title *The Modern Cult of Monuments*; institutional constraints would have precluded Riegl from being explicit, and lead him to prefer these "falsely aesthetic" (Choay 2000a: 141) references. |
| | **- historical** | The historical value that all monuments, by definition, hold, stems directly from them constituting "evidence that seems to represent especially striking stages in the development of a particular branch of human activity" (1996: 70). Of course, which historic stages are considered 'especially striking', and thus valued, is a societal choice; Riegl thought the first manifestations of this valorization to have come into light during the Renaissance.<br>N.B.: there is a relationship between historical and age values, since not only the appreciation of the latter inherently presupposes a certain (even if just basic) knowledge of art history, but also, and more importantly, the recognition of the age value naturally develops the perception of historical value (1984). |
| | **- deliberate** | Depends on prospective valorization (as opposed to retrospective valorization): the object was built with the intention of celebrating a certain moment and of passing it on to the future. By definition, deliberate monuments aspire at an "eternal present" (Riegl 1996: 78) that can only be achieved through protective laws and restoration procedures that maintain the monument in its *Werdezustand* (original form). |
| | **<u>Contemporaneity values/present-day values</u>** – not exclusive of heritage objects but, in what they can meet the expectations and requirements that societies would normally deposit in newly created works, heritage objects may (and indeed do, in most cases) incorporate present-day values. | |
| | **- use** | Granted to objects that are called upon to serve any given function. If, on the one hand, it is known that the utilization of the built heritage is vital for its preservation, it is no less true that the replacement of every historical building by a modern one constructed to serve the same purpose is not realistically conceivable, as already noticed by Riegl in the dawn of the 20th century. Furthermore, it is worth noting that the age value, "based on the perception of the lively play of natural forces" (1996: 79) expects that monuments are made use of when possible, and would be diminished otherwise. |
| | **- art**: it may be decomposed into 'newness' and 'relative art' values; a heritage object will hardly possess a fully consistent newness value, as it will, to a higher or lower degree, have suffered consequences from the passing of time. It is entirely possible, however, that thje object, regardless of its age, is imbued with relative art value, either positive or negative (see below). | |
| | ***newness*** | Conflicting opposite of the age value. Arises from the "completeness of the newly created [...] expressed by the simple criteria of unbroken form and pure polychromy" (1996: 80). |

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| | | The progression of weathering and decay upon a monument will distance it further and further form the modern *Kunstwollen* (artistic volition – see ‘relative art’). The newness value is, in fact, an elementary requirement of the art value, inasmuch as it existed in any age of the history of art in the appreciation of a work of art in its completion and absence of degradation. |
| | ***relative art*** | Rooted in what disrupts the *Kunstwollen* (artistic volition) of each art period from that of preceding ones; related to “the specificity of the monument in what concerns its conception, its form and its colours” (1984: 94). The term “relative” emphasizes not only that it cannot be objectively formulated, but also that it is an ever changing art value requirement. It may be positive, if “the monument pleases our contemporary artistic volition” (1984: 112); or negative, when “a monument appears shocking, stylistically awkward and ugly to the contemporary artistic volition” (1984: 115)<br>The immediate corollary is that “newness value has always been the art value of the mass majority of the less educated or uneducated; whereas relative art value […] could only be evaluated by the aesthetically educated” (Riegl 1996: 80).<br>N.B.: Literally, the ‘art-will’, or artistic volition, *Kunstwollen* seems to refer to contemporary artistic drive (or impulse) that constantly sets artistic value requirements. According to Jokilehto, Riegl introduced, for the first time, “a teleological conception of art” (Jokilehto 1986: 378): “Alois Riegl coined the concept of *Kunstwollen* to indicate the relationship of human creative activity with the relevant cultural context. *Kunstwollen* also referred to the regeneration of representational forms that contributed to what could then become a ‘style’” (Jokilehto 2006: 8) |
| R. Lemaire (1938) | “Lemaire maintained that historic buildings could have four types of values: use value, artistic value, historical-archaeological value and picturesque value, and that the aim of restoration should be to maintain or augment each of these values as far as possible. In a case when there was a risk that one of these values might be diminished, the results should be judged from the point of view of benefit to the whole.” (Jokilehto 1986: 390) The sequence should be as follows:<br>“a) To establish as precisely as possible the coefficients of the various current values of the building from the four perspectives outlined [below].<br>b) To examine what would happen to these coefficients in the case of an intervention and in the case of no intervention.<br>c) To balance the results and see which solution will give the building, in the future, the maximum value." (Lemaire, cited in Jokilehto 1986: 402) | |
| | **Use** | “All architectural work must be considered firstly from the point of view of its capacity for use” (Lemaire, cited in Jokilehto 1986: 401). |
| | **Artistic** | “But architecture is not aimed uniquely at achieving usefulness; it is also an art” (Lemaire, cited in Jokilehto 1986: 401). |
| | **Historical-archaeological** | “[architecture] is notably an historical and archaeological document” (Lemaire, cited in Jokilehto 1986: 401).<br>According to Jokilehto, Lemaire agreed with Louis Cloquet’s 1893 division of historic buildings into ‘living’ and ‘dead’: ‘living’ historic buildings “had a contemporary use” (Jokilehto 1986: 389) and included, for example, churches and palaces; ‘dead’ historic buildings, “such as pyramids, temples, and ruins, [had] mainly documentary value” (Jokilehto 1986: 389). |
| | **Picturesque** | “Besides this triple character: use, artistic and documentary, every building can also possess a fourth: the picturesque character” (Lemaire, cited in Jokilehto 1986: 401-402). Lemaire considered picturesque values to be “of less importance when dealing with ‘living’ historic buildings.” (Jokilehto 1986: 390) |
| The Burra Charter (1st version 1979; latest revision 2013) | According to the Burra Charter, retaining cultural significance is the primary goal of conservation, and the values which consubstantiate this significance are “listed alphabetically” to emphasize the fact that no value is in principle more important than the others. The Charter further states that these are not by all means restrictive and thus other value categories may be found necessary or useful when characterizing the significance of a place. | |
| | **Aesthetic** | “refers to the sensory and perceptual experience of a place—that is, how we respond to visual and non-visual aspects such as sounds, smells and other factors having a strong impact on human thoughts, feelings and attitudes. |

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| | | Aesthetic qualities may include the concept of beauty and formal aesthetic ideals. Expressions of aesthetics are culturally influenced" (2013a: 3). |
| | **Historic** | Defined as an underlying value relatively to the others, for embracing aesthetical, scientific and social history; it is imbued in any place that "has influenced, or has been influenced by, an historic event, phase, movement or activity, person or group of people [or that was] the site of an important event" (2013a: 3). |
| | **Scientific** | "refers to the information content of a place and its ability to reveal more about an aspect of the past through examination or investigation of the place, including the use of archaeological techniques. The relative scientific value of a place is likely to depend on the importance of the information or data involved, on its rarity, quality or representativeness, and its potential to contribute further important information about the place itself or a type or class of place or to address important research questions." (2013a: 3) |
| | **Social** | "refers to the associations that a place has for a particular community or cultural group and the social or cultural meanings that it holds for them." (2013a: 4) |
| | **Spiritual** (added in 1999) | "refers to the intangible values and meanings embodied in or evoked by a place which give it importance in the spiritual identity, or the traditional knowledge, art and practices of a cultural group. Spiritual value may also be reflected in the intensity of aesthetic and emotional responses or community associations, and be expressed through cultural practices and related places.<br>The qualities of the place may inspire a strong and/or spontaneous emotional or metaphysical response in people, expanding their understanding of their place, purpose and obligations in the world, particularly in relation to the spiritual realm.<br>[…] Spiritual values may be interdependent on the social values and physical properties of a place." (2013a: 4) |
| J.S. Kerr (1st ed. 1982; latest version 2013) | James Semple Kerr, one of the authors of the first Burra Charter draft, offers 'Criteria for assessing cultural significance': "It is important to stress that the criteria outlined below form only one of a number of possible approaches to assessment and that no general set is likely to be entirely appropriate for any single place. Hence it is undesirable to seek the universal application of standard criteria. Instead, questions on significance should be tailored to each project after the assessor has analysed the documentary, physical and contextual evidence." (2013: 12) | |
| | **Ability to demonstrate** | Should include all aspects, actual or potential, pertaining to the evidential importance of the place, i.e., to the ability of the place ("and its components") to serve as testimony of (i) "philosophies or customs"; (ii) "designs, functions, techniques, processes, styles"; and (iii) "uses, and associations with events or persons" (2013: 12). |
| | **Associational links without surviving evidence** | Even when there is no (physical) evidence, either because it never existed or because it did not survive, there may be associational values that confer significance to the place; these may have to be investigated via literary or sociological research.<br>"Irrespective of whether evidence survives or not, places can have associational significance for a variety of reasons. These may include incidents relating to exploration, settlement foundation, Aboriginal-European and Maori-European contact, massacre, disaster, religious experience, literary fame, technological innovation, notable discovery and popular affection." (2013: 14) |
| | **Formal or aesthetic qualities** | The statement of these must go beyond description alone; specific features may be "assessed under the conventions of scale, form, materials, textures, colour, space and the relationship of components" (2013: 15) or others deemed useful or necessary, and context should be added in a way that makes their contribution to the overall significance apparent.<br>Examples of assessment questions include:<br>"• has the place a considerable degree of unity in its scale, form and materials?<br>• does the place have a relationship between its parts and the setting which reinforces the quality of both?" (2013: 15) |
| Lipe | Lipe proposed that certain materials that have survived from the past are kept because of their | |

<table>
<tr><td rowspan="5"></td><td colspan="2">character as cultural resources, i.e., because they may “be of use and benefit – in the present and future” (1984: 2). In this sense, the author speaks of resource values – “to the extent that value is defined in relation to some end or use” (1984: 2), which underlines that, of course, some advantages are expected from conserving given objects. Basically, objects inherited from the past will be potential cultural resources; these will be evaluated within specific social contexts and they will be deemed worth preserving if resource values are recognized. According to Lipe, four types of resource values exist:</td></tr>
<tr><td>Associative/ symbolic</td><td>“ability that [cultural resources] have to serve as tangible links to the past from which they have survived” (1984: 4), i.e., of functioning as “symbols of, or mnemonics for, the past” (1984: 4). Symbols make intra- and intergenerational cultural transmission possible: to use tangible objects as symbols permits social groups to broaden the information fund beyond the capacity of the human brain – “Because they are durable, material items are the most stable kinds of symbols” (1984: 5).</td></tr>
<tr><td>Informational</td><td>Refers to the fact that all past objects are, to a higher or lower degree, sources of information about the periods they crossed. The associative/symbolic value of cultural resources is strongly conditioned by the knowledge that societies possess about them; this knowledge may be traditional or common in character, or it may stem from scholarly research, which will eventually influence common perspectives held by non-specialists.<br>The informational potential of cultural resources is only fully realized if “we have the wit to ask the right questions and the methods with which to extract the appropriate answers” (1984: 6). The key to extracting this knowledge lies heavily in formal research, which is crucial to accomplish the symbolic role that past materials possess. For periods where documentation is scarce, surviving objects will be the primary sources of knowledge; but even if documentation is abundant for a given period, the objects then created will be able to supplement, corroborate and/or shed new light in the existent knowledge.</td></tr>
<tr><td>Aesthetic</td><td>Relates to the aesthetic appeal that certain objects exert over their observers because of their shape, form, colour and/or other sensory qualities. While there is an individual component to this appeal, there will also be a strong influence of social standards and overall cultural contexts to which the individual belongs to, and even of the contexts where the object originated from.</td></tr>
<tr><td>Economic</td><td>In what they coexist, and often compete, with other resources today, heritage objects, and decisions pertaining to them, will necessarily have an economic facet. One of the most relevant components to this value comes from the utilitarian dimension of some cultural objects, “which derives not from a property’s connection to a past cultural context, but from its ability to serve a present-day material need” (1984: 8). Other manifestations of economic values are conveyed by the resources (especially time and money) spent by individuals to gain access to heritage objects; in these cases, people pay to access the symbolic and/or aesthetic values of the cultural resource, although this spending does not directly translate them: “though economic value can be one indicator of public support for cultural resources and one tool for preservation of and public access to these resources, it cannot be our only criterion for what should be saved and managed for public enjoyment and education. (1984: 9)</td></tr>
<tr><td>S. Michalski (1992)</td><td colspan="2">Michalski suggests that the overall value of an object may be represented in a multidimensional value space, and specifically proposes that this value may be plotted in a 3D graph with three ‘primary dimensions’: perceptual, knowledge and emotional values, the first two of which may be further expanded to encompass other dimensions. “Each object plots differently for each individual, although individuals from a given community will plot similarly, and perceptual value will tend to plot more similarly across all individuals than knowledge value.” Furthermore, “this is a value judgment, all axes [of any 3D value graph] can be given negative directions as well” (1992: 248)<br>In other words, “We process perceptions and knowledge [and emotions], both banal and profound, when confronting artefacts. Modern museology is obsessed with knowledge, particularly social constructs. Traditional connoisseurship focuses on perception, especially aesthetic refinements, Conservation has been trapped by narrow subsets: scientific knowledge and the perception of defects” (1992: 245)</td></tr>
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| | **<u>Knowledge</u>** | |
| | **- personal narrative** | "Narrative knowledge uses rules of denotation, prescription, evaluation, performance, etc. It takes the form of stories, legends and myths, about for example, truth, justice and beauty. These transmit our social bond, and were once pre-eminent, but are now considered primitive or ideological." (1992: 242) The proposal of these knowledge values is based on the "senses of the past" of a community: "The first, common to all, is the personal sense of the past which relies on memory and attachment to places and things. The second, which is dominated by the educated and affluent, is the sense of an impersonal heritage which overlays the personal sense of the past. The impersonal heritage is that which has no direct connection with one's personal past, being expressed in terms of the history of other people, of the region, the nation, or the world." (Merriman, cited in Michalski 1992: 243) |
| | **- impersonal narrative** | |
| | **- scientific** | "Scientific knowledge limits itself to rules of denotation, such as argumentation, proof, and consensus between initiates." (1992: 242) |
| | **<u>Emotional</u>** – not defined in the consulted source. | |
| | **<u>Perceptual value</u>**: "comes from our five senses." (1992: 248) Within the specific scope of conservation, this value may be related to: | |
| | **- recreated** | Perceptual value attached to restored or remade areas of the object. |
| | **- remaining original** | Perceptual value attached to the areas of the object that are perceived as original, i.e., "scientifically authentic to its birth" (1992: 250). To be distinguished from recreated areas requires a knowledge discourse. |
| | **- defects** | "the value we give to defects depends both on perceptual training and cultural knowledge. Thus the dimension «defects» has both positive (patina) and negative (damage) directions, and rather than compute a net value, I suggest that people hold ambivalent judgements about defects" (1992: 250) |
| B. Feilden (1993, 2003) | "For both movable and immovable cultural property, the choice of specific objects for treatment and the degree of intervention are directly related to the values passed by society on different cultural property. These values help to establish on a systematic basis overall priorities in scheduling interventions, as well as to programme the extent and nature of individual treatments. The assignment of values or priorities will inevitably reflect each different cultural context." (1993: 3) Furthermore, Feilden defines heritage values in the context of sustainability, aligning concerns on heritage conservation, particularly of historic buildings, with the comparatively more popular ones supporting environmental conservation. | |
| | **<u>Emotional</u>**: "those which we can all feel without necessarily being able to articulate them clearly" (1993: 3). "It may be difficult to differentiate from the various emotional values but they can be taken collectively and graded from the weak to the very strong." (1993: 4) | |
| | **- wonder** | "placed first as anyone, when confronted by an artefact, should question, «What is its significance?», «Who made it?», «How was it made?», «How has it survived?». In short one simply wonders at the miracle of artistic creation." (1993: 3) |
| | **- identity** | "Sites, monuments and objects all contribute to our feeling of *identity*. A town that has lost its monuments is like a person who has lost his memory and so has lost its identity." (1993: 3, italics in the original text) |
| | **- continuity** | "confers legitimacy and reassures us when we face the future. The older we become the more we value continuity which is some assurance against projections indicating future disasters, such as atomic warfare, atmospheric pollution or the greenhouse effect." (1993: 4) |
| | **- respect & veneration** | "*Veneration* is an emotion related to the respect for, or belief in, the history or myths that are attached to an object or site. […] Respect is sensitivity for the feelings of those who venerate a site or object." (1993: 4, italics in the original text) |
| | **- symbolic & spiritual** | "*Symbolic values* depend on culture and tradition" (1993: 4) and our ability to perceive and understand these symbols: "*Symbolic and Spiritual feelings* depend on cultural awareness." "*Spiritual values* can come from evidence of past piety and from the present statement of the [object] and its site" (1993: 4, |

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| | | italics in the original text) |
| | **Cultural**: "appreciated by educated persons and defined by specialists and scholars. Therefore there can be much debate about their relative order of importance in a specific case. It may be difficult to reach an agreement on their order of precedence, yet this is vital if any proposed intervention is to be executed successfully" (1993: 4) For example, 'documentary', 'archaeological' and 'architectural' values may demand specific courses of action, which have to be considered if one of these values is prevalent: "it is important not to destroy [historic] evidence as scholars may wish to review and reinterpret it. It is the evidence which must be recorded"; "In conservation, archaeologists place great value on retaining original material in situ"; "in order to preserve architectural values, retention or reproduction of the design is important." (1993: 5) | |
| | **- aesthetic** | "vary with culture and fashion but gradually a consensus prevails. These values are established by the critical methods of art historians and there is a time lag before the general public can accept a revised view. […] The graph of aesthetic appreciation is generally lowest thirty years after the work of art was produced and rises thereafter." (1993: 4) |
| | **- artistic** | "subjective. The more recent the oeuvre the more subjective is the evaluation. […] artistic values change from generation to generation. […] However, the older the work of art, the more consistent are the expert's opinions as to its significance and artistic value." (1993: 4-5) Feilden suggests that these shifts may threat the values of buildings, which "are expected to be usable, whether a great oeuvre or not" (1993: 4) and thus are likely to endure adaptations. As for portable objects, the author warns against using market values to calculate artistic value. |
| | **- art historical** | "Art historical valuations are even more complex [than artistic valuations] depending on the studies of the career of the artist, the influences that affected him and the assessments of his techniques, his intentions and achievements. Historical periods tended to evolve recognizable styles peculiar to the contemporary ethos which had a particular way of thinking and seeing which permeated to cultural activities. [… Art historians] can give a subjective assessment of the current importance of the work of art." (1993: 5) |
| | **- documentary** | "Objects and buildings convey the most complete records of past civilizations. Documentary values are simply the historic evidence provided by the artefact" (1993: 5). |
| | **- historic** | "similar [to documentary values] – an event happened there or the object belonged to an historic person, and it helps us to understand that person" (1993: 5). |
| | **- archaeologi-cal** | "involve the unexplored potential of a building or site to give information. These are easily destroyed if unsupervised excavation takes place […] The archaeological values and authenticity of [an] object depend on maximum retention of original material." (1993: 5) |
| | **- age** | "involve scarcity. Due to natural decay, objects and buildings of certain types become more and more rare, so, extant examples become valuable." (1993: 5) |
| | **- architectural** | "Architectural values were defined by Sir Henry Wooten as 'commodity, firmness and delight'. Delight covered the artistic element in architecture, such as the relationship of the building to the site, the massing and silhouette, the proportions of the elements as a whole, the size of the elements relating to human dimensions, the appropriateness of materials and decoration, and the significance of the building in the hierarchy of its city's or country's heritage. […] Firmness relates to the building's structure, which must resist the loads imposed by various categories of use, as well as wind, snow, earthquakes—in seismic zones, and its own weight. […] Firmness includes durability.<br>Commodity relates to the usefulness of the building. If it cannot be used beneficially and becomes obsolete, it is subject to economic threats. […]<br>The supreme architectural values are, however, spatial and environmental. It is by walking through an architectural ensemble that one senses its quality, using eyes, nose, ears and touch." (2003: ix) "Architectural values are related to the |

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| | | participants' movement through spaces, to his sensations, which are not purely visual in these spaces, to his interest in decorative plastic and sculptural treatment of significant forms and spaces. This, together with his pleasure in the colour and texture of the material, also in his appreciation of harmony, scale, proportion and rhythms, given by the elements of design with their underlying geometry, contribute to the values. Because all the participants' senses are involved, a building that functions badly has low architectural value" (2003: ix) |
| | **- technological & scientific** | "Appreciating the technological achievements […] in a fine building or sculpture tells us a great deal about the civilization which created them. […] Technological & scientific values are found in pioneering structures. […] The significance of a site can be almost entirely technological" (1993: 6). |
| | - **landscape & ecological** | "generated by climate and underlying geology." (1993: 6) Includes the influence of the landscape in artistic works and the landscapes influenced by human construction. "Monuments cannot be divorced from their landscape" (1993: 6) |
| | **- townscape** | "depend upon ensembles of buildings, the spaces they stand in, with treatment of surface paving, roads and public spaces […] Townscape also includes views from significant reference points and vistas. Interest in townscape is found by walking around admiring fine buildings, going down narrow streets into open spaces […]<br>The urban setting of monuments is also vital to their appreciation, as such buildings were designed for their specific site, be it a street, a square or a market place […] Analysis of the quality of a town includes the compression and opening of space, formal spaces, surprises, drama and set pieces of architecture." (1993: 6) |
| | **Use**: "The use values of artistic objects, historic buildings and sites are not necessarily favourable to the preservation of their cultural values" (1993: 6) | |
| | **- functional** | "The original functional use may still be possible, but the object may be too valuable to use […] Buildings can retain their functional value for centuries. Machines may often become obsolete and so lose their functional value while retaining their scientific and historical value. Functional values are important assets in building rehabilitation schemes." (1993: 6) |
| | **- economic** (incl. tourism) | Corresponds to market value: "generally, with objects that can be sold, the economic value is far above from its functional value, relating to its aesthetic and scarcity value […] If the value of a city site exceeds the value of the building on that site, than it is at risk of development because it has become obsolete. We cannot turn cities into museums, nor can we afford preservation of everything old. In conservation we must seek to manage change so that the greatest amount of our heritage can be saved. This means finding an economic use that is harmonious with the cultural values in the old buildings so as to minimise any loss of authenticity." (1993: 7)<br>One of these 'economic uses' is tourism, although "Unless conservation activities counteract the destructive aspects of tourism, there is an acute danger that tourism will destroy the very values that the tourist has travelled far to absorb." (1993: 7) |
| | **- social** (incl. identity & continuity) | "largely covered by emotional values, but are also related to the sense of belonging to a place and a group." (2003: x) "Social values are difficult to define. Certainly buildings which help to give citizens a sense of identity and continuity have social values. Buildings which illustrate social history by including how past generations have lived, should have social values." (1993: 7) |
| | **- educational** | "easily recognized by the study of history, especially economic and social history, as historic buildings provide much of the evidence. One of the prime motivations in architectural conservation is to provide educational opportunities." (2003: x) |
| | **- political** | "Political values are not so difficult to define. Historical buildings and |

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| | | archaeological sites can be used to establish the history of a nation in people's minds […] Nations that have established themselves rather recently are prone to use historic sites as an element of their political programmes, in order to confirm their identity." (1993: 7)<br>"There are, indeed, political values in conservation; a minister can gain great publicity by some large restoration programme. Unfortunately the thousands of minor acts that constitute a programme of preventative maintenance do not win the same political mileage as one major act […] Due to the political pressures applied by religious and ethnic groups, conservation work is often distorted, and such groups often wish to rewrite history" (1993: 7) |
| T. Darvill (1994) | Darvill sets out for a sociological interpretation – as opposed to a monetary perpective – of the value systems applied to 'the archaeological resource': "Values in this sense, divorced from and to some extent set in opposition to, monetary value, represent fundamental and inescapable constituents of social action, socially conditioned, unevenly distributed, and differentially ranked standards, ideals, and understandings by which individuals and communities define goals, select courses of action, and judge themselves and others. Value systems are the very things that underpin and inform individual and collective attitudes and, by implication, approaches to the physical and experiential environment." (1994: 52)<br>"In the context of cultural resource management the understanding of value systems of different sorts, and the place within those systems of the resources with which we are concerned, is an important foundation upon which theory, method and practice are based." (1994: 52) "At the heart of any value system is a logical construct which is not directly observable but which can be understood through inference and abstraction from what is said and done. The stimuli which create and update value systems are complicated, not least because values are held by individuals, but shared (to a greater or lesser extent) by communities." (1994: 53) The author focuses "on value systems relating to the archaeological resource in late 20th century western, mainly European, society." (1994: 53)<br>"At its most simple, a social value is generally taken to be a conception of the desirable, whether explicit or implicit, distinctive of an individual or characteristic of a group, which influences the selection and orientation of social action from available modes, means, and ends." (1994: 53)<br>"Knowledge, both as a component of value formation, and as a stimulant to change in value systems, is critically important. […] Trust between members of society is a major feature of the way that values are shared between people, and in modern societies it must be recognised that expert knowledge is widely trusted and relied upon. Values and empirical knowledge are connected in a network of mutual influence. […] archaeologists are both participants in the application of value systems through being members of society, and generators of more widely adopted values because they are experts in their field." (1994: 54) | |
| | **Use:** "value system based upon the fact that demands or uses are placed upon the archaeological resource by contemporary society […; it] is based on consumption […] Society's ability to use the archaeological resource depends on two things which are in practice contributions by experts with expert knowledge. First is the existence of some evidence, record or memory of things we are trying to draw upon, and second our ability to attribute meaning to what we have." (1994: 55)<br>For Darvill, use values are reflected in the ends or goals with which a past resource is used in the present. Some examples are given below, "but they are constantly changing and new uses of the past are constrained only by the limits of our imaginations to invent them." (1994: 56) | |
| | **archaeological research** | An "obvious use": "the discovery of information or knowledge about the past" (1994: 56) by archaeologists. |
| | **scientific research** | "Scientific research [other than archaeological] of many kinds uses data drawn from archaeological sites" (1994: 56). |
| | **creative arts** | Many different "Artists […] draw inspiration from archaeological […] objects in their own translations and renegotiations of the material world into visual, literary, or oral images […], and the uses of the aesthetic qualities of ancient objects are as numerous now as they ever have been" (1994: 56). |
| | **education** | "The archaeological resource plays a substantial role in the general education of children and adults." (1994: 56-57) |
| | **recreation & tourism** | Many objects of an eminently archaeological character, among which Stonehenge or Hadrian's Wall are particulary prominent examples, are important visitor attractions. |

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| | **symbolic representation** | "Whether the popularity of archaeological sites with tourists is caused by, or gives rise to, abundant symbolic uses of images of archaeological sites is not really known" (1994: 57), but Stonehenge is again a blatant example of this kind of use. |
| | **legitimation of action** | "Archaeological evidence is frequently used to support or legitimise particular propositions, especially politically motivated propositions." (1994: 57) |
| | **social solidarity & integration** | "use of archaeological remains to bolster social solidarity and promote integration. [Some think] this end alone justified the continuance of archaeological endeavour and its consequent costs." (1994: 57) |
| | **monetary & economic gain** | May be legitimate: "selling of books and publications about archaeological sites, guided tours, production of souvenirs, and so on"; or illegitimate: "robbing of monuments and the sale of the antiquities so plundered." (1994: 57) |
| | **<u>Option</u>**: "hinge on a projected understanding that future generations will both want and be able to make some use of the resources in question – the idea that we have a duty to those who follow. The main quality of the archaeological resource which is essential to the acceptance of this value is the question of potential." (1994: 58)<br>"[T]he temporal context of this value system is not the present but rather some unspecified time in the future. [… its] goal-orientation is the physical preservation of remains in order to achieve the notional preservation of options" (1994: 58). | |
| | **stability** | "Adherence to option values […] inhibits change and enhances the perception of stability, timelessness and tradition. Re-creation and restoration of times past is an important dimension. Elements of the past become celebrated for what it might be rather than what it is." (1994: 58) |
| | **mystery & enigma** | "Within a society in which knowledge is usually controlled and manipulated as a key element in the support of power relations the existence of knowledge-gaps which are nonetheless human creations could be rather important." (1994: 58) Stonehenge is again presented as an example of this value. |
| | **<u>Existence</u>**: "relates simply to the existence of the resource. The temporal context is the present […] Central to the realisation of these values is the recognition of a set of feelings of well-being, contentment, and satisfaction […] These feelings are triggered in people who may never expect to use or see the resource itself by knowing it exists" (1994: 59)<br>"The interest-base of these values is the psychological imperative in having a past, knowing of its well-being, without necessarily doing anything about it." (1994: 59) | |
| | **cultural identity** | "Identity is established and reinforced by knowledge of the existence of a past, albeit one that is not always fully understood or very well-known." (1994: 59) |
| | **resistance to change** | "a predominant theme of protests against change is the galvanising of interest in some previously almost unnoticed structure or institution." (1994: 59) There is also "the notion, often expressed, that historical precedent legitimates action on the assumption, explicit or implicit, that what has been should continue to be or be again." (1994: 59) |
| Mohr & Schmidt (presented in the 1996 Dahlem Workshop; printed in 1997) | Mohr & Schmidt are mainly concerned with heritage valuation, i.e., the economic measurement of heritage values, and particularly its nonuse values, which are not directly obtainable by "what is commonly understood as consumption" (1997: 333), i.e., the market. The authors propose to utilize tools developed for the valuation of "nonmarketable natural resources" (1997: 334) in the obtaining of both the use and nonuse values of heritage: "In addition to a possible nonuse value, objects of cultural importance may possess values associated with consumption activities, such as tourism or any other activities that require some kind of physical proximity to the object. An object's total value must clearly be determined by combining both use and nonuse values, ideally in an additive fashion." (1997: 334) This system offers a measurement of societal value where expert opinion counts as much as non-expert opinion.<br>The authors furthermore highlight that "Value and valuation are always dependent on purpose. […] Different purposes define different counting rules" and thus, "In our analysis, we *presume* that the exclusive purpose of [heritage] valuation is as an ingredient in a public cost-benefit analysis [CBA]." (1997: 335, italics in the original source) CBA is, according to Mohr & Schmidt, the most adequate framework for dealing with "societal investment projects" (1997: 335). The purpose of the suggested value system is, therefore, "to quantify the benefit portion of a cost-benefit analysis of investing into [cultural heritage] protection" (1997: 335). In this context, the relevant values are | |

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<tr><td></td><td colspan="2">use, nonuse and diversity values. It should also be noted that “the valuation of cultural objects and, consequently, the ranking of their relative value does not imply that the conservation resources should necessarily be concentrated on the items at the top of such a ranking list. This decision depends on the costs of conservation. Hence, in principle, the rational allocation of scarce resources may require one to give up a specially valuable object that would be extremely costly to preserve, in order to protect a greater number of objects of lesser individual value.” (1997: 340)<br>Yet another difficulty in valuing heritage objects derives from their public good nature: most heritage objects are nonrival in character, i.e. their consumption by an individual does not preclude their consumption by other individual(s). “The nonrivalry in consumption requires that the group of (potential) users and visitors must not be restricted too much. Especially when the nonuse values are considered, the relevant group whose preferences and values should be considered and aggregated in the valuation process might be very large […as in] e.g. items on the World Heritage List” (1997: 344, italics in the original source).</td></tr>
<tr><td></td><td colspan="2"><u>Total (use + nonuse)</u>:<br>“economic valuation techniques presume that individual’s preferences over goods, including cultural heritage, possess the property of substitutability, that is, individuals are willing to make trade-offs” (1997: 337) – thus allowing for “the application of the so-called compensating surplus measure of welfare change” (1997: 337, italics in the original text). In a CBA for the purposes of conservation, the total value corresponds to the monetary value of the ‘compensating surplus measure of welfare change’, i.e., “the difference between the expenditure level which originally brought about the reference welfare level (before [any changes to] the object in question) and the higher expenditure level which just suffices to bring about the same welfare level after the decline [caused by the change in the object]” (1997: 337).</td></tr>
<tr><td></td><td><u>Use</u></td><td>“Use value of a nonmarket object [e.g. a public good] is typically defined by a linkage to the consumption of some suitable marketable commodity […e.g.] journeys to an historic site, lodging, or entrance fees” (1997: 338). “If the theoretical preconditions are fulfilled, use value can be determined by asking what reduction in travel costs, lodging or entrance fees is required to keep a constant welfare” (1997: 338, italics in the original source) should there be an undesirable change in a given characteristic of the object.<br>Still, “use valuation is relatively easy for objects that possess a spatial isolation property and whose societal role can be define in one or few dimensions. Use valuation becomes, however, more difficult the more facets there are to an object and the more it is part of ordinary life, such as, for example, the use value of historic centres.” (1997: 338)</td></tr>
<tr><td></td><td><u>Nonuse</u></td><td>IF it is possible to define a use value as defined above, then nonuse value is “definable as the value that is attributable to the object if the price of the linked market commodity is so high that demand for it is zero. It is either zero or positive.” (1997: 338)<br>On the other hand, IF the above mentioned given characteristic of the object “possesses some minimum value at which the object ceases to exist and use becomes impossible” (1997: 338), then nonuse value may be further divided into ‘simple nonuse value’ and ‘pure existence value’.<br>“Use value, simple nonuse value, and pure existence value possess the adding-up property making total value the sum of all.” (1997: 338, italics in the original source)</td></tr>
<tr><td></td><td>- simple nonuse</td><td>“related to the decay of an object that continues to exist” (1997: 338). Contemplates the loss of cultural characteristics in still (physically) existing objects.</td></tr>
<tr><td></td><td>- pure existence</td><td>“relates to an object’s destruction [e.g. by fire… This] would be […] a suitable value for undertaking a cost-benefit analysis for emergency measures where time and money allow only a selective minimum conservation.” (1997: 338)</td></tr>
<tr><td></td><td>- option price</td><td>Risk-associated value: “Consider the value of reducing the risk to someone who is confronted with a dual uncertainty. The person neither knows for sure whether it will cherish the object in the future nor whether the object will be available if he or she does. In this situation, the person might be willing to pay a premium over the expected use value to assure the certain availability of the object in the future. The maximum premium that the individual is willing to pay</td></tr>
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| | | to eliminate the supply uncertainty is the *option price*. If it is positive, it enters into the total value of conservation.” (1997: 338, italics in the original source)<br>(Not to mistake for ‘option value’, which “is a mathematical artefact due to inconsistent definitions of what constitutes a welfare-preserving change under uncertainty in its formula.” (1997: 339)) |
| | **Diversity** | “use and nonuse values tend to obscure variety. Variety may be considered, however, a key aspect of an ensemble of cultural objects […] Cultural valuation must therefore also address the issue of how to define the value of cultural variety.” (1997: 334)<br>“[Cultural heritage diversity] is a necessary ingredient into the development of a policy instrument that allows a rational decision as to which ensembles to preserve and which to give up, which objects to include in ensembles of local, regional, national or global importance, and how to allocate scarce conservation funds” (1997: 345)<br>Such a measure was developed for intra-species (environmental) diversity, and although it was not a monetary metric, there was a strong economic dimension to it, given that diversity preservation requires resource allocation. However, (in 1996) there was yet no application of diversity theory to cultural heritage, and the authors propose a simple diversity function as a weighed sum “where each cultural characteristic [“e.g. style, site, history”] enters the metric in a weighed form, representing the relative importance of the characteristic for cultural distance [between heritage objects].” (1997: 347)<br>This development would require interdisciplinary research: “cultural experts would come up with the relevant characteristics […] and economists or other social scientists would have to try to find the weighs […] by means of surveys or other direct and indirect methods” (1997: 347).<br>This would also have to include a measure for change: “With respect to buildings, a measure for change could be the rate of decay of walls. With paintings it could be the rate at which colours fade, and so forth.” (1997: 347) |
| Carver (1996, republished 2013) | Carver focuses on the definition of ‘archaeological value’ in the larger context of “Competing values in the struggle for the use of the land” (2013, fig.1), meaning to encompass not only the values of the (archaeological) object proper, but also considering the values of the resources that must be sacrificed in order to preserve the object: “This analysis concentrates on the values championed by the main players competing for their right to exploit (i.e. change) a piece of land. Each value stands for groups of interested parties with their own agendas” (2013: 298) | |
| | **Market** | These are measurable in monetary terms and include:<br>- “capital/estate value;<br>- production value (including agriculture, mineral extraction, etc.);<br>- commercial value;<br>- residential value.” (2013, fig.1) |
| | **Community** | “[t]hose intended to benefit society more widely and more generally, for example […] the construction of roads, park, sewers, schools or hospitals. The success of such amenities may also be measured in money, at least partly; more crucially their perceived benefits are measured in votes.” (2013: 298) Votes are suggested by the author to be a mechanism that allows communities to change their “definition of the ‘public good’”(2013: 299). Community values include:<br>- “amenity value (provides something to be shared with the community);<br>- political value (a vote winner);<br>- minority/disadvantaged/descendant value (wins the support of the disaffected);<br>- local style value (rather than aesthetic, which is unknowable) (wins the support of the elders)” (2013, fig.1) |
| | **Human** | This “third and most difficult category [cannot be supported] on the prospect of profit or votes, but on grounds of a generalized morality” (2013: 299). It includes “environmental value” and “archaeological value” (2013, fig.1).<br>In order to advocate for *archaeological value*, archaeology must be:<br>• anticipatory: “able to do this [define the archaeological value of an object] in advance, […] rather than make claims for it retrospectively” (2013: 300); |

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| | | •professional: "its case must be professionally made and professionally presented" (2013: 300);<br>•demonstrable: "able to 'document' the value it awards a particular site or landscape" (2013: 300);<br>•authoritative: "able to demonstrate 'authority' for its value, if not consensus, within the profession" (2013: 300);<br>•global: "it must insist on the 'global' (not national) character of its definition and the universal nature of its clientele." (2013: 300)<br>Carver defends that archaeological objects should be mostly valued because of their research potential, as opposed to their 'monumental value' (most commonly used at the time): "the concept of monument, and the ways to define monuments, contain a built-in obsolescence, because both tend to endow the future more liberally with examples of the identified, rather than the unidentified archaeological resource. Research, in contrast, favours the unknown." (2013: 304)<br>For archaeology, "the value of the unknown greatly exceeds that of the known. That is not to say that the monuments [/objects] already defined by an earlier generation have no value – far from it: they are works of reference for our current knowledge, the point of departure for new exploration. […] In this sense, a monument is a memorial to knowledge won, and its criterion for curation could be as a form of 'publication' for research […] Monuments are supposed to represent the consensus of a given national history. Research is supposed to represent the aspirations of all mankind" (2013: 306).<br>"*Archaeological value* derives from the *character of the deposit* on the one hand and the *research agenda* on the other; what we can know out of all we want to know, at a particular place, now." (2013: 308, italics on the original text) |
| Deeben et al. (1999) | According to Deeben et al., "valuation and selection [of archaeological objects] must take into account both a site's societal value and its value for (future) academic research. […] In the system presented here, the former will be found in the attention given to perception value; the latter in the valuation of the physical and intrinsic qualities of [an object] or group of [objects]" (1999: 180), "[V]aluation cannot be separated from its social and academic contexts." (1999: 190)<br>In this system, the different values are to be assessed sequentially. | |
| | **<u>Perception value</u>**: Attempts to mirror the societal value of the object: objects are "evaluated in terms of criteria that reflect their perception value. This can be subdivided into 'aesthetic value' and 'historical value'. Perception value can serve as a tool for preserving especially that which is visible. It is about appreciation of archaeological heritage from the public's point of view." (1999: 180)<br>"[A]rchaeological [objects] may contribute significantly to the aesthetic, educational and recreational quality of an area. [Objects] with a high perception value are pre-eminently suitable to generate popular support for the protection of archaeological [objects] in general." (1999: 184)<br>In this system, objects may be deemed worth preserving on the account of their perception value alone. | |
| | **- aesthetic value** | "refers to the value of archaeological [objects] as part of the landscape, which can generally be translated as visibility. This criterion centres on the external appearance of the [object], in the sense of its condition, shape and texture in relation to its surroundings. Aspects to be considered include the [object]'s visibility as a landmark, its links with other (visible) [objects] or geographical features and its setting in the landscape; in brief: the degree to which a monument may please by its external characteristics.<br>The concept of aesthetic value is barely ever used in archaeological practice. Operationalizing aesthetic value as 'visibility' produces a workable criterion." (1999: 183) |
| | **- historical value** | "relates to the memories of the past that [the archaeological object] evokes. […] In most cases, such memories are linked to a field [object], but […] a place with no visible remains may still function as a *lieu de mémoire*. Two different kinds of historical value may be distinguished. There is a rare category [of objects] which is directly connected with historical events": either "relating to relatively recent historical events whose memory has lived on" or with a connection |

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| | "established through excavations and/or other research" – "This implies that historical value may also be created by archaeological interpretation. A second category is made up of [objects] that are not linked with actual historical events, but have traditionally been associated with myths and legends, or to which religious importance has been attached, or which for other reasons play a role in people's perception of the landscape. […] The former category […] should always be classified as worth preserving." (1999: 183, italics in the original source) |
| **Physical quality**: Together with the 'intrinsic qualities' below, it intends to encompass the value of the object as a source of academic knowledge, present and future: "This [assessment in terms of physical criteria] takes into account [an object]'s physical quality, using the criteria of 'integrity' and 'preservation' […] This reflects the aim of preserving high-quality [objects]." (1999: 181)<br>"Physical quality is the degree to which archaeological remains are still intact and in their original position." (1999: 184) The authors suggest for 'physical quality to be assessed using a method proposed by Groenewoudt in 1994, which, the authors assert, "it is found to work well, in the sense that experts regard the results as relevant and its application by different experts produces identical or at any rate very similar results." (1999: 184)<br>Both criteria may be scored from 1 (low) to 3 (high). If the object was not considered worth preserving on the grounds of perceptual value, it may become so on the grounds of physical quality – if the sum of both criteria is above 5 or 6 – *and* intrinsic quality – which must score above 7. | |
| **- integrity** | "degree to which disturbance has taken place" (1999: 184). Assessed parameters: "presence of features; integrity of features; spatial integrity; intact stratigraphy; movable finds in situ; spatial relations among movable finds; spatial relations between movable finds and features; survival of anthropogenic biochemical residues" (1999: 197). |
| **- preservation** | "degree to which the archaeological materials have survived" (1999: 184). Assessed parameters: "preservation of artefacts (metal/other); preservation of organic material" (1999: 197). |
| **Intrinsic quality**: "[Objects] are evaluated in terms of their scientific importance. Scientific value is established on the basis of four criteria: rarity, research potential, context or group value, and representativity. These criteria may be applied at more than one spatial scale: at the level of the individual [object/site] and that of micro-regions containing several [objects/sites]. At this stage, the aim of preserving intrinsic quality is further substantiated, and opportunities are created for realizing the objective of retaining a representative stock of [objects/sites]." (1999: 181-182)<br>For objects that do not score above seven, it must be ascertained if they should be preserved on the grounds of the representativity criterion (which is not numerically scored).<br>All objects with below-average values and not meeting the representativity criterion "will be classified as 'not worth preserving'" (1999: 190) | |
| **- rarity** | "degree to which a certain type of [object] is (or has become) scarce in a period or region. Rarity is therefore a relative notion. […] To determine rarity value, we need insight into the extent and variety of the archaeological heritage of [the country], how much of it is left and the condition it is in. […] This assessment therefore requires a "detailed inventory of knowledge and gaps in our knowledge. […]<br>The assessment of rarity is based on a score [… which] is assessed as 'low' (score 1), if there are a large number of similar, coeval [objects] in the region which are in a similar or even better state of preservation […] Rarity is judged to be 'high' (score 3) if the [object] is unique or very few similar [objects] survive in the region. In all other cases [including cases where evidence is insufficient], a 'medium' score will ensue." (1999: 185) |
| **- research potential** | "significance of the [object] as a source of knowledge about the past. […] This may equally be the closing of gaps in such knowledge or the opportunity to formulate alternative interpretations of the past […] Hence the question is not only whether new evidence is expected to fill lacunae, but also whether it is expected to be relevant to current research needs. Further, is should be noted that research potential is also determined by [an object]'s 'group value'. The research potential of a complex of [archaeological objects] in an archaeologically and geographically coherent ensemble usually exceeds the sum |

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| | | of its component parts.<br>[…] The research potential score of [an object] is based on an analysis of lacunae in knowledge and current research objectives. […] Different types of knowledge lacunae may be distinguished, which may or may not occur in combination: (a) geographical knowledge lacunae […]; (b) chronological knowledge lacunae […] and (c) intrinsic or thematic knowledge lacunae […]<br>Research potential is generally 'high' if the rarity value scores highly, but the other scores may differ: even about common types of [object] there may be knowledge lacunae, whereas [an object] that scores 'medium' on rarity value may belong to a category about which much is known." (1999: 187) |
| | **- context or group value** | "extra value that [an object] gains through still having an archaeological and/or geographical context. 'Archaeological context' refers to the presence and the research potential of nearby sources of archaeological evidence. This may be a synchronic context […] or a diachronic context.<br>'Geographical context' is the degree to which the original geographical context is still present or recognizable […]<br>[An object]'s group value is determined on the basis of its 'close vicinity'. Thus it is not the archaeo-region as a whole that counts, but the micro-region (also referred to as an 'archaeological-geographical ensemble' or 'community area'), which is usually the basic geographical unit in archaeological research […]<br>If neither context [archaeological or geographical] has survived to any significant extent, group value is recorded as 'low'; if one of either is not or is no longer present or is seriously disturbed, the score is 'medium' and if both are extant to a significant extent, group value will be 'high'." (1999: 188) |
| | **- representati-vity** | "degree to which a certain type of [object] is typical of a period or an area (chronological or chorological representativity). […] in contrast to rarity, research potential and group value, representativity is relevant only if eventual conservation of the [object] is an option. This is inherent in the definition and operationalization of the concept. […] The typicality of [an object] may be determined both quantitatively and qualitatively. In its qualitative sense, the concept of typicality may relate to specific views about the interpretation of material culture […] The greater the number of known, similar [objects] from the same period and the same part of the country […] the more 'representative' individual [objects] will be. […]<br>'Representative' [objects] should preferably have a high group value. In principle, archaeological-geographical ensembles scoring highly on synchronic and diachronic context will include many 'typical' archaeological [objects]. By definition, such [objects] will score 'low' on rarity and 'medium' on research potential." (1999, p.188-189) |
| J. Ashley-Smith (1999) | "Value is a social construct dependent on social relationships. […] Value is bound to change through time and between cultures. It is not always possible to get close agreement on value. We cannot know exactly how values will change in the future." (1999: 81)<br>"[Value] is an extrinsic property that cannot be directly detected by the senses, it does not exist without a social context. The value of an object can only be derived by comparison with the values of other objects or actions. This comparison is often achieved by exchange, where the values of the exchanged objects are considered to be the same. […] There are many types of value, some of which come from comparisons of objects, some of which come from comparisons of feelings" (1999: 82)<br>"For many applications, we do not need to have an absolute value, we are primarily interested in *changes* of value. […] We may be able to ignore some of the most difficult contributions to value if we are convinced that they will not change in the circumstances we are considering [e.g. historical association to a deteriorating object] […] In many cases we do not need to give an absolute value to the change but can content with an assessment of the proportional or percentage change in value." (1999: 83, italics in the original text) | |
| | **Economic** | "those defined by transactions that are easily described in terms of monetary units, or of utility, which can be related to money. The greater the demand to use a collection, the greater its value." (1999: 84)<br>In the words of other authors: "use, exchange, monetary" (1999, Table 6.1) |
| | **Informational** | "those that arise from hidden or exposed information that can be gleaned from |

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| | | an object or its associated documentation." (1999: 85)<br>In the words of other authors: "documentary, scientific, perceptual" (1999, Table 6.1) |
| | **Cultural** | "very dependent on time and place. They are heavily influenced by the spirit of the time (*Zeitgeist*), but often have to be learned through understanding of religious iconography or philosophical vocabulary." (1999: 85)<br>In the words of other authors: "symbolic, spiritual, social, political" (1999, Table 6.1) |
| | **Emotional** | "can only be distinguished from cultural values by the fact that they are more personal and probably more difficult to articulate." (1999, p.85)<br>In the words of other authors: "aesthetic, personal narrative" (1999, Table 6.1) |
| | **Existence** | Describes the satisfaction withdrawn from knowing a given (heritage) good exists (but not from actually using it). |
| | N.B.: The values listed above are "broad categories" (1999: 84) that may be influenced by diverse factors: "factors that might contribute to a single concept of value. […] They might contribute to a sense of loss if evidence of those factors was destroyed by decay or vandalism" (1999: 85): "• Age • Rarity • Material • Complexity • Quality • History • Identity • Information • Context • Potential • Condition" (1999, Table 6.2) | |
| R. Mason (2002) | The value system proposed below "—which is neither exhaustive nor exclusive—is offered as a point of departure and discussion. [… It] includes the kinds of value most often associated with heritage sites and conservation issues, but it does not assume that every heritage site has every type of value. […] any value typology should serve only as a starting point and that value types will have to be adjusted and revised for each project/setting." (2002: 10-11)<br>Mason separates values under the two main headings of 'cultural' and 'economic': "the economic-cultural distinction is widely shared and remains a very useful analytic convenience. […] economic and cultural spheres represent two quite distinct attitudes/perspectives toward the subject of values and valuing." (2002: 10) Therefore, "Economic and cultural are two alternative ways of understanding and labeling the same, wide range of heritage values. […] The major difference between them resides in the very different conceptual frameworks and methodologies used to articulate them." (2002: 11) | |
| | **Sociocultural values**: "values attached to an object, building, or place because it holds meaning for people or social groups due to its age, beauty, artistry, or association with a significant person or event or (otherwise) contributes to processes of cultural affiliation" (2002: 11). The subcategories below "are not distinct and exclusive; in fact, they overlap quite extensively" (2002: 11). | |
| | **- historic** | "The capacity of a site to convey, embody, or stimulate a relation or reaction to the past is part of the fundamental nature and meaning of heritage objects. Historical value can accrue in several ways: from the heritage material's age, from its association with people or events, from its rarity and/or uniqueness, from its technological qualities, or from its archival/documentary potential.<br>There are two important subtypes of historical value that merit mention. *Educational/academic value* is a type of historical value. The educational value of heritage lies in the potential to gain knowledge about the past in the future through, for instance, archaeology or an artist's creative interpretation of the historical record embodied in the heritage. *Artistic value*—value based on an object's being unique, being the best, being a good example of, being the work of a particular individual, and so on—is also a type of historical value." (2002: 11) |
| | **- cultural/ symbolic** | "Cultural values are used to build cultural affiliation in the present and can be historical, political, ethnic, or related to other means of living together (for instance, work- or craft-related). As used in this typology, cultural/symbolic value refers to those shared meanings associated with heritage that are not, strictly speaking, historic (related to the chronological aspects and meanings of a site).<br>*Political value*—the use of heritage to build or sustain civil relations, governmental legitimacy, protest, or ideological causes—is a particular type of cultural/symbolic value." (2002: 11) |

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| | **- social** | “The social values of heritage enable and facilitate social connections, networks, and other relations in a broad sense, one not necessarily related to central historical values of the heritage. The social values of a heritage site might include the use of a site for social gatherings […] that do not necessarily capitalize directly on the historical values of the site but, rather, on the public-space, shared-space qualities. […]<br>Social value also includes the «place attachment» aspects of heritage value. Place attachment refers to the social cohesion, community identity, or other feelings of affiliation that social groups (whether very small and local, or national in scale) derive from the specific heritage and environment characteristics of their «home» territory.” (2002: 12) |
| | **- spiritual** | “spiritual values can emanate from the beliefs and teachings of organized religion, but they can also encompass secular experiences of wonder, awe, and so on, which can be provoked by visiting heritage places” (2002: 12) |
| | **- aesthetic** | “In the main, aesthetic refers to the visual qualities of heritage. The many interpretations of beauty, of the sublime, of ruins, and of the quality of formal relationships considered more broadly have long been among the most important criteria for labelling things and places as heritage. […] the category of the aesthetic can be interpreted more widely to encompass all the senses: smell, sound, and feeling, as well as sight. Thus, a heritage site could be seen as valuable for the sensory experience it offers. Aesthetic value is a strong contributor to a sense of well-being and is perhaps the most personal and individualistic of the sociocultural value types.” (2002: 12) |
| | **<u>Economic values</u>**: “According to neoclassical economic theory, economic values are the values seen primarily through the lens of individual consumer and firm choice (utility) and are most often [though not always] expressed in terms of price.” (2002: 12) Contrarily to the sociocultural subcategories, the economic subcategories below “are intended to be distinct and exclusive of one another.” (2002: 11) | |
| | **- use (market)** | “refer to the goods and services that flow from it that are tradable and priceable in existing markets. For instance, admission fees for a historic site, the cost of land, and the wages of workers are values.” (2002: 13) |
| | **- nonuse** | “economic values that are not traded in or captured by markets and are therefore difficult to express in terms of price. […] many of the qualities described as sociocultural values are also nonuse values. They can be classed as economic values because individuals would be willing to allocate resources (spend money) to acquire them and/or protect them. […] The economics field describes nonuse values as emanating from the *public-good qualities* of heritage—those qualities that are «nonrival» (consumption by one person does not preclude consumption by someone else) and «nonexcludable» (once the good/service is provided to anyone, others are not excluded from consuming it).” (2002: 13) |
| | • *option* | “refers to someone’s wish to preserve the possibility (the option) that he or she might consume the heritage’s services at some future time.” (2002: 13) |
| | • *existence* | “Individuals value a heritage item for its mere existence, even though they themselves may not experience it or “consume its services” directly.” (2002: 13) |
| | • *bequest* | “stems from the wish to bequeath a heritage asset to future generations.” (2002: 13) |
| Brooks & Eastop (2006) | Using the problematics raised by textile cleaning, Brooks & Eastop attempt the identification of “dominant paradigms in conservation practice” and their underlying cultural assumptions, so that these may be “recognized and questioned” (2006: 171).<br>More specifically, “Deciding whether to clean a textile [or any other object] will be influenced by a sense, whether consciously or unconsciously expressed, of what the piece should be like” – “a correct appearance or form” (2006: 172). In turn, “The complexity of the ways in which this correctness is viewed depends on the fact that all culturally significant objects are socially ambiguous”, and “Recognizing the nonmaterial properties of a culturally significant artefact changes the approaches to both interventive and preventive conservation”. (2006: 172) | |

<table>
<tr><td></td><td colspan="2">The authors identify four different paradigms guiding decisions on the cleaning of (heritage) textiles and analyse what are their consequences at intervention level.<br>As the recognition of new values (or paradigms) develops, “Conservation cleaning proposals therefore must engage the issue of balancing physical benefits to the artifacts against changes in symbolic value.” (2006: 174)<br>“Different stakeholders [“including owners, curators, and conservators” (2006: 179)] may define the value of an artifact in different elements – the object itself, the soiling, or in the evidence derived from this. A focused debate on the goal of […] interventions […] is important. All decisions need to be supported by documentation explicitly recording the rationales as well as what was done. Why a treatment was implemented – or was not implemented – should be as important as what the treatment actually was.” (2006: 178)</td></tr>
<tr><td></td><td>Domestic paradigm</td><td>“approaches dominated by the ethos of hygiene and household laundry” (2006: 172) (where ‘laundry’ could possibly be replaced for ‘tidiness’ in the case of different object tipologies.)<br>“deciding what is dirty is culturally defined, and [under this paradigm] moral properties are ascribed to states of dirtiness and cleanliness”, since “The idea of cleanliness and goodness as the polar opposites of dirtiness and badness is deeply embedded in many cultures” and “Cleanliness is not just godly, it is also an indicator of social status” (2006: 172). So, “the domestic paradigm affects all of life and therefore inevitably affects conservation practice”, and “It is still appropriate in some cases, for example, where white cotton vestments or table linen in historic houses are still in use. Here the role of the textiles is to represent godly and/or hygienic purity” (2006: 173).<br>The fact is that “Conservation cleaning techniques do differ from those of the housewife but it is important to recognize that the underlying – and often unstated – assumptions about the moral value of cleanliness may influence conservation decisions.” (2006: 173) Therefore, “When its power is not recognized and it remains unexamined, this paradigm may be influential by default, with the result that textiles may undergo cleaning for reasons other than their long-term preservation.” (2006: 173)</td></tr>
<tr><td></td><td>Sacred & heroic paradigm</td><td>“approaches adopted for relics, whether sacred […] or secular” (2006: 172)<br>In the case of relics, staining may be connected with the person and/or event responsible for the object becoming a relic in the first place; in many cases, the staining may be main (or even sole) source of the object’s significance.<br>Thus, under this paradigm, “stains «function as both remainder and reminder of what has come to pass: both evidence and memory»” (Sorkin, cited in Brooks & Eastop 2006: 173) and become “«’holy dirt’ which has become part of the history of the object and, as such, must not be removed.»” (Landi, cited in Brooks & Eastop 2006: 174)</td></tr>
<tr><td></td><td>Art-historical paradigm</td><td>“approaches influenced by aesthetics or ideas of authenticity” (2006: 172)<br>This paradigm “focuses on recovering the form of a textile and/ or its aesthetics and hence establishing its status within the art-historical canon.” (2006: 174-175) “The art-historical paradigm has been championed by art historians and connoisseurs rightly concerned that the object be seen as clearly as possible” (2006: 175-176).<br>“the importance of the art-historical paradigm may be attributed to the fact that Western society prioritizes the image in those artifacts that it defines as fine art.” (2006: 176)</td></tr>
<tr><td></td><td>Evidential paradigm</td><td>“approaches prioritizing historical, forensic, or legal value(s) attributed to soiling” (2006: 172).<br>“soiling […] can be viewed in different ways […: it] may be considered as an unwanted agent of deterioration that should be removed, or the same soiling could be considered a source of valuable information. Context is important here” (2006: 176) – and so are future uses.<br>“the evidential paradigm recognizes that soiling may be of profound significance and that deciding to remove it will be influenced by the institutional, legal, and philosophical context as well as technological capacity. The evidential paradigm can function as a decision-making tool to interrogate the domestic and the art-historical paradigm. Appearance may not be all that</td></tr>
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| | | matters." (2006: 178) |
| B. Appelbaum (2010) (1st edition 2007) | The values below correspond to "the values that can affect the interpretation of an object and therefore influence treatment goals. […] The values can be divided into two categories, personal and cultural. Personal values are those held by owners and perhaps their families. Cultural values are those held by a broad group of people or society at large. Most objects that conservators treat have both kinds of value, so the distinction has no affect on their treatment." (2010: 89) If an object holds only personal value, however, this may have implications in treatment decisions.<br>"Values almost inevitably shift with changes in use or ownership because the meaning of certain qualities of the object depends on context." (2010: 117) | |
| | **Art** | "any object considered to be art has art value." (2010: 89) Objects may be considered art 'by intention' – "Objects with no intended physical function occupy a central position in the category of things we call «art», but this is only true for objects that also have other attributes of art, such as aesthetic value or the creator's intent that the work *be* art." (2010: 90, italics in the original text) – or 'by appropriation' – "Art-ness often resides in the ideas applied to the viewing of objects rather than objects themselves. […] Much of what we now categorize as art was not «art» in the modern sense when it was made. […] [Some of these objects] were created for other purposes: religion, politics, music, [etc…] In a sense, society *creates* art by appropriation". (2010: 90-91, italics in the original text). In this appropriation, contemporary society applies "modern ideas about «artists» [… and namely a] belief in the centrality of personality and individual creativity in the making of objects." (2010: 91)<br>"Art has values other than the aesthetic, but aesthetic remains a central feature" (2010: 91).<br>"Making something into art makes it the common property of people other than those from its culture of origin" (2010: 91) |
| | **Aesthetic** | "while art value is clearly a shared, and therefore a cultural, value, aesthetic value by itself is a personal one. […] Most objects with aesthetic value have other values that give them meaning for a broad range of people. There are, however, several kinds of objects with no value other than the aesthetic." (2010: 91)<br>"An object has aesthetic value when it is prized for how it looks […] Aesthetics refers to beauty in the broad sense of visual appeal. Aesthetic value can arise from high levels of craftsmanship, ingenuity, a creative and skilled use of materials, appealing colour or design, and even signs of age or deterioration (2010: 91). |
| | **Historic** | "recognizes objects as bearers of information about history. Objects with historical value have an authentic link with a particular historical event or time period. […] The category does not cover objects valued for their technical information (see research value), or objects that just look old (see age value).<br>The historical value of an object depends on the existence of information outside of the object. […] Because of the shared public nature of history, historical value is a cultural value" (2010: 95-96) |
| | **Use** | "refers to things that are valued for their usability […] all objects have uses, [… but that] meaning of «use», however, makes the idea too broad to be helpful, and we will confine the term to mean only physical function. […] Objects in active original use (that is, the use the object was made for) can present treatment problems that do not exist when they have been taken out of use and put into a collection. Conservation codes of ethics seldom address the problems peculiar to objects with primarily use value" (2010: 97-98). |
| | **Research** | "The classic case of objects with primarily research value is biological and geological specimens." Scientific reference collections are based on taxonomy and have specific research purposes that change over time. […]<br>Research value can, of course, also be found in historical and functional objects and works of art. […] Archival collections are fundamentally research collections […] Virtually every object contains information about its history and technology and can be useful for comparison with similar objects.<br>Cultural objects [or their decay history] can also be the source of information |

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| | | about something other than the object itself" (2010: 102-103) |
| | **Educational** | Some objects are exhibited or used "for demonstration in order to convey specific information such as their mode of operation or construction. […] When historical objects, rather than replicas, are used for this purpose, the object is apt to be a routine example of a common type and therefore replaceable. The object's educational value outweighs its historical value." (2010: 104) |
| | **Age** | "An object has age value when it *is* old, it *looks* old, and we *like* that it looks old. Age is a value when the viewer feels it enhances the appeal of the object rather than detracting from it." (2010: 104, italics in the original text) Appelbaum's definition directly follows the one by Riegl.<br>"Even if an object is valued for its look of age, that age value does not create cultural value if the object is not valued in some other way. To treasure something primarily because it is old is a personal preference unrelated to expert or public opinion and is not sufficient to give something cultural value. Age value is therefore a personal value." (2010: 107) |
| | **Newness** | "An object has newness value when it *looks* new and we *like* that it looks new. The object does not actually have to *be* new for the newness value to apply." (2010: 108, italics in the original text) |
| | **Sentimental** | "springs from individual's direct personal experience with objects [… and] usually does not outlive one owner of an object, but can survive if the object is passed down through the generations." (2010, p.109) "Sentimental value can also attach to a museum object that has become part of visitor's personal memories" (2010: 111)<br>"An object may have sentimental value for more than one reason, and each reason can give rise to a different treatment choice." (2010: 109) Sentimental values are of a "time-limited nature" and "If an object has other values, those will become the ruling ones in due time." (2010: 110)" |
| | **Monetary** | "often used as a convenient indicator of overall cultural value. As such, it is a very inexact, and sometimes deceptive, measure. Market value depends not only on an object's intrinsic qualities but on many extrinsic factors as well. New information on authorship or subject matter, the medium of the object, changes in styles of interior decoration, auction prices of similar items, and major museum exhibitions all affect market value. The relative monetary value of objects of particular styles and types and of works by particular artists shifts over time to a greater extent than most people realize." (2010: 111) |
| | **Associative** | "Objects with associative value have connections to a person with a considerable amount of fame, either as the object's owner, user, or creator. […] While the passage of time is necessary for historical value, associative value can arise when objects are new and can disappear just as quickly as the fame of the connected person melts away. The judgments of history may eventually turn associative value into historical value" (2010: 112-113). |
| | **Commemora-tive** | "derives from the intent of the commissioning group or institution at the time the object was created" (2010: 113) Defined following the definition of Riegl: "The focus of interest for object with primarily commemorative value is what the monument commemorates rather than its creation. Value rests in the appearance of newness rather than period authenticity" (2010: 113) |
| | **Rarity** | "based on the number of similar objects in existence. But rarity is non-material because it is based on human judgement, not on numbers. Only objects with substantial cultural value qualify, and unusual or unique things may have no value at all." (2010: 114)<br>"Rarity can be relative to locale […] Rarity intensifies other values. […] The effect of rarity on the values of objects varies widely. […] Outside a sentimental value, […] a lack of rarity reduces the possibility that an individual object will acquire cultural value." (2010: 114-115) |

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| English Heritage (2008) | The division of values below is not rigid – it may accommodate some adjustments to the specificities of a particular site; for example, a category of 'Natural' value may be be appropriate. | |
| | **Evidential** | Based in the ability that places have to function as documents of past periods. This value generally augments with potential for knowledge gain, age and scarcity of other sources of knowledge for the context in question; it diminishes with removals or replacements.<br>For example, for Hadrian's Wall, this value was decomposed in: complexity, group value, archaeological evidence, landscape value, scale, rarity and international influence (HWMPC 2008). |
| | **Historical** | Either *illustrative* or *associative*, historical value resides on the ability of a place to link past and present people:<br>• *illustrative* value relies on visibility and "has the power to aid interpretation of the past through making connections with, and providing insights into, past communities and their activities through shared experience of a place" (2008: 29);<br>• *associative* value ensues from places that are linked to "a notable family, person, event, or movement" (2008: 29).<br>Historical value is generally not as reduced by change as evidential value: "The authenticity of a place indeed often lies in visible evidence of change as a result of people responding to changing circumstances. Historical values are harmed only to the extent that adaptation has obliterated or concealed them, although completeness does tend to strengthen illustrative value" (English Heritage 2008: 29). |
| | **Aesthetical** | Relatable to "the ways in which people draw sensory and intellectual stimulation from a place" (2008: 30), these values may yield from (conscious) design or from fortuitous evolutions in the use of the place, and these may combine or conflict. Design values vary with the quality of both design and execution, as well as with the innovative character of the place. |
| | **Communal** | Deriving from "the meanings of a place for the people who relate to it, or for whom it figures in their collective experience or memory" (2008: 30). These include:<br>• *commemorative* and *symbolic* values, when places act as sources of identity or evoke an emotional response from (at least some) people;<br>• *social* value also exists in places "that people perceive as a source of identity, distinctiveness, social interaction and coherence" (2008: 32);<br>• *spiritual* value, which is linked to feelings of worship, wonder, inspiration or reverence one experiences in a place.<br>For Hadrian's Wall, this value was unfolded into: academic value, educational value, recreational value, social value and economic value. |
| K. Van Balen (2008) | Values are defined as "different layers that define the authenticity of the built heritage" (2008, p.39). The system was developed as a "framework that would present the relationship between this [traditional Western] material-technical approach with one that would also include the impact of craftsmanship." (2008: 40). The author seems to consider 'significance' as synonyms with 'authenticity': "Studies that aim at protecting, promoting, or conserving a monument are based on the identification and evaluation of the heritage values inherent to it, i.e., understanding the authenticity of it and considering it as a layered concept of values. (2008: 40)<br>Because it is based on definitions ensuing from the Nara Document, this value system was dubbed 'The Nara Grid'; it is presented as a table, where each 'Aspect' should be analysed in its different 'Dimensions'. Neither the 'Aspects' nor the 'Dimensions' were defined by the author in any of the consulted sources; only a few examples of application are given. | |
| | **Aspects** | Form and design<br>Materials and substance<br>Use and function<br>Tradition, techniques and workmanship<br>Location and setting<br>Spirit and feeling |
| | **Dimensions** | Artistic<br>Historic |

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<tr><td></td><td></td><td>Social<br>Scientific</td></tr>
<tr><td></td><td colspan="2">Examples of application for the Grand Château Water Tower (all citations from 2008: 43):<br>• ‘Form and design’ x ‘Historic’: “The water tower is one of the few examples left in the Brussels region and without any evident alteration. It is the last example of its type.”<br>• ‘Materials and substance’ x ‘Scientific’: “Interests in industrial heritage: evidence of materials and technology used for this type of «building machines»”.<br>• ‘Use and function’ x ‘Artistic’: “Specific expression of water tower of the nineteenth century; combination of two towers; forms follow function but with certain expression typical of the nineteenth century engineering”<br>• ‘Tradition, techniques and workmanship’ x ‘Scientific’: “Possibility to study ancient techniques and craftsman ship (e.g., the iron tank).”<br>• ‘Location and setting’ x ‘Social’: “The position of the tower is strategic to the past urban development of the neighbourhood; today it is strategic for the valorization of the Bois de la Cambre cultural landscape.”<br>• ‘Spirit and feeling’ x ‘Historic’: “It shows the approach in the nineteenth century of how to deal with semi-public places in relation to a cultural landscape.”</td></tr>
<tr><td rowspan="6">R.Russel & K.Winkworth – Significance 2.0 (2009)</td><td colspan="2">The values defined below were conceived as criteria to be used for the assessment of significance, i.e., “the process of researching and understanding the meanings and values of items and collections.” (2009: 10)<br>“Using a consistent set of criteria facilitates more accurate analysis and helps elucidate the unique characteristics and meanings of each item or collection.<br>All criteria are considered when making an assessment, but not all will be relevant to the item or collection. One or more criteria may apply and be interrelated. It is not necessary to find evidence of all criteria to justify that an item is significant. […]<br>The criteria are a prompt for describing how and why the item or collection is significant. They will have different shades of meaning depending on the type of item or collection under consideration.” (2009: 10)</td></tr>
<tr><td colspan="2"><u>Primary criteria</u></td></tr>
<tr><td>- historic</td><td>Depends on the answers to the following:<br>“• Is it associated with a particular person, group, event, place or activity and how is this important?<br>• What does it say about an historic theme, process, or pattern of life?<br>• How does it contribute to understanding a period, place, activity, industry, person or event?” (2009: 39)</td></tr>
<tr><td>- artistic or aesthetic</td><td>Depends on answers to the following:<br>“• Is it well designed, crafted or made?<br>• Is it a good example of a style, design, artistic movement or an artist’s work?<br>• Is it original or innovative in its design?<br>• Is it beautiful, pleasing, or well-proportioned?<br>• Does it show a high degree of creative or technical accomplishment?<br>• Does it depict a subject, person, place, activity or event of interest or importance?” (2009: 39)</td></tr>
<tr><td>- scientific or research potential</td><td>Depends on the following:<br>“• Do researchers have an active interest in studying the item or collection today, or will they want to in the future?<br>• How is it of interest or value for science or research today or in the future?<br>• Is it of research potential and in what way?<br>• What things in particular constitute its scientific or research interest and research value?” (2009: 39)<br>N.B.: In this system, historical value takes precedence over scientific value: “Items such as historic scientific instruments are generally of historic significance.” (2009: 39)</td></tr>
<tr><td>- social or spiritual</td><td>“Social or spiritual significance is always specific to a particular, identified group of people.” (2009: 39) It depends on the following:<br>“• Is it of particular value to a community or group today? Why is it important to them?<br>• How is this demonstrated? How is the item kept in the public eye, or its</td></tr>
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| | | meaning kept alive for a group? For example, by use in an annual parade or ceremonies, or by maintaining traditional practices surrounding the item.<br>• Has the community been consulted about its importance for them?<br>• Is it of spiritual significance for a particular group?<br>• Is this spiritual significance found in the present?<br>• Does it embody beliefs, ideas, customs, traditions, practices or stories that are important for a particular group?" (2009: 39)<br>N.B.: "This type of significance only applies to items and collections where there is a demonstrated contemporary attachment between the item or collection and a group or community. Items or collections of social history interest are of historic significance." (2009: 39) |
| | **Comparative criteria**: these are used as modifiers of the primary (main) criteria for the evaluation of the degree of significance. They are not sufficient to grant significance per se, although they might increase or decrease an object's significance as assessed according to the criteria above. | |
| | **- provenance** | "life story of an item or collection and a record of its ultimate derivation and its passage through the hands of its various owners. […] Provenance depends on good record keeping" (2009: 15) and it "is often the key to an item's historical significance" (2009: 16). Provenanced items are the building blocks of artefact histories and a reference point for similar unprovenanced items." (2009: 16)<br>Provenance may be assessed by answering the following questions:<br>"• Is it well documented or recorded for its class or type?<br>• Who created, made, owned or used the item or collection?<br>• Is its place of origin well documented?<br>• Is there a chain of ownership?<br>• Is the provenance reliable?<br>• How does the provenance shape the significance of the item or collection?" (2009: 39)<br>N.B.: "Provenance is part of the research in the assessment process as well as a comparative criterion." (2009: 39) |
| | **- rarity or representative ness** | Assessment should answer the following:<br>"• Does it have unusual qualities that distinguish it from other items in the class or category?<br>• Is it unusual or a particularly fine example of its type?<br>• Is it singular, unique or endangered?<br>• Is it a good example of its type or class?<br>• Is it typical or characteristic?<br>• Is it particularly well documented for its class or group?" (2009: 40) |
| | **- condition or completeness** | Depends on the following:<br>"• Is it in good condition for its type?<br>• Is it intact or complete?<br>• Does it show repairs, alterations or evidence of the way it was used?<br>• Is it still working?<br>• Is it in original, unrestored condition?" (2009: 40) |
| | **- interpretive capacity** | Related to:<br>"• How is it relevant to the organisation's mission, purpose, collection policy and programs?<br>• Does it have a special place in the collection in relation to other items or a collection theme?<br>• Does it help to interpret aspects of its place or context?" (2009: 40) |
| U. Meneses (2009) | The values listed below correspond to "the main components of cultural value"; these "do not exist isolated and may be grouped in various ways, yielding combinations, re-combinations, juxtapositions, diverse hierarchies, transformations, conflicts." (2009: 35) | |
| | **Cognitive** | "If (or when) [the object] has conditions for knowledge, or constitutes an opportunity for knowledge – any knowledge – then the dominant value is cognitive. Through it, we can learn about the concept of space that organized the building [/object], its materials and techniques, its stylistic pattern; we can |

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| | | trace the effects of the interests at stake in its projecting, the historical (technical, economic, political, social, cultural) conditions of its construction, uses and appropriations, the different social categories or agents involved, its trajectory, its biography. The [object] is then being treated as a document, to which questions are addressed in order to obtain, as answers, information of multiple natures. It is a value of essentially intellectual fruition." (2009: 35) |
| | **Formal** | "When [the object] is perceived as a qualified opportunity for sensorial gratification and for deepening the contact between my «I» with the «transcendent» or «external world», then the predominant value is formal or aesthetical.<br>I use *aesthetical* here in its original sense, from the Greek, *Aísthesis*, meaning perception. I am not referring to beauty, the beautiful form, the systems of beauty, non-universal, historically mutable canons. Aesthetics is about that fundamental bridge provided by the senses that enables us to leave ourselves, to build and interchange meanings to act upon the world. It is, here, about the effect of the presence, in objects, of attributes capable of sharpening perception, of leading to a deeper apprehension, of inducing a wider production and transmission of senses – fed by memory, conventions and other experiences – qualifying my conscience and my acting. Aesthetics is, thus, a mediation that makes us humans. It does not coincide with styles, although formal attributes of styles may, precisely, sharpen my perception, qualifying it." (2009: 35-36, italics in the original source) |
| | **Affective** | "The values that we usually name historical (but pertaining to memory, and not to controlled knowledge), would be better framed by the category of affective values. They are not exactly historical, since they are about the formulation of a self-image and the strengthening of identity. They are affective, because they are a part of *subjective connexions* that one establishes with certain objects […] It is useful to remember: memory and History neither coincide nor are opposite sides of the same coin. Therefore, if we are dealing with History as critical production of knowledge, then we are in the realm of cognitive values […]. If we are concerned with the symbolic load and subjective connexions, like the feeling of belonging or identity, then the realm is that of affective values. […] [T]heir assessment cannot be confused with opinion polls, and even less with the signing of petitions or similar displays. It involves complex mechanisms, like social representations and social imaginations, for which Social Psychology has developed appropriate research methods." (2009: 36, italics in the original source) |
| | **Pragmatic** | "These are more than use values. […][One] looks for a temple to pray, although it is not indispensable, likely [because] the conditions of available use are capable of relevantly adding quality to [one's] practice, also because of pragmatic values. In other words: pragmatic values are use values perceived as qualities." (2009: 37) |
| | **Ethical** | "These are values linked, not to the objects, but to the social interactions under which they are appropriated and worked [/used], using the position of the other as reference. […] A discussion on ethical values would demand dealing with thorny issues such as relativism (cognitive, cultural, moral), and cultural rights versus human rights – issues that are out of the scope of this context. It should, however, be noted that, if the right to culture is the right to difference, the latter is only legitimate when it is capable of dialogue and of producing mutual transformations.<br>Without it, the much talked about multiculturalism may become a smoke screen where a certain universalism (which paradoxically allows for diversity) masks norms, values and interests […] It is therefore convenient, today, to distinguish between *cultural diversity* and *cultural difference*. Homi Bhaba is incisive when saying that liberal tradition (particularly in anthropological and philosophical relativism) has pacified and generalized the idea that cultures are diverse and that, in a way, the diversity of cultures is something good and positive in and for itself, and that it should be automatically endorsed. That way, it would be a democratic-society commonplace to say that it incentivizes |

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| | | and accommodates cultural diversity. In truth, however, the sign of a «civilized» attitude in Western societies is […] the ability of appreciating diverse cultures, but as in an «imaginary museum». When the cultures leave the museum and the *cultural difference* (and not just cultural diversity anymore) becomes one of the active components of social tensions, the encouraging of cultural diversity is accompanied by mechanisms of cultural difference containment. In other words, it has been occurring, with the same subjects, that cultural diversity may be greatly appreciated in museums, even though it is rejected in social interaction. The reactions facing cultural traits and facing the actual bearers of the culture may not coincide.” (2009: 37-38, italics in the original text) |
| | Brief note on economic (trade) value: “In the perspective I developed, there is no antagonism [between cultural and economic values]. There is an economic dimension to the cultural good, just like there is a cultural dimension to the economic good. […] Opposition exists, yes, between the logic of culture (which is a logic of finality, where the production of sense and communication is the priority […]) and the logic of the market (which tends to instrumentalize culture towards the obtaining of profit).” (2009: 38) | |

# Appendix B: Examples of immovable heritage official designation systems

| Country | Designation | Level of importance (higher to lower, for each country) |
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| Portugal | ‘National monument’ (‘monument, ensemble or site’ of national interest) | “whenever their protection and valorization, in whole or in part, represents a cultural value of nationwide significance” (*Lei 107/2001 - Lei de Bases do Património Cultural* 2001: art.15) |
| | Public interest object (object: ‘monument, ensemble or site’) | “whenever their protection and valorization still represents a cultural value of national importance, but for which the protection rules governing the classification of national interest prove disproportionate” (*Lei 107/2001 - Lei de Bases do Património Cultural* 2001: art.15) |
| | Municipal interest object (object: ‘monument, ensemble or site’) | Whenever their “protection and valorization, in whole or in part, represents a cultural value of predominant significance for a given municipality” (*Lei 107/2001 - Lei de Bases do Património Cultural* 2001: art.15) |
| United Kingdom | ‘Scheduled monuments’ (1) | Monuments of national importance scheduled under the Ancient Monuments and Archaeological Areas Act (1979); Under the direct authority of the Secretary of State for the Environment. |
| | ‘Listed building’ (1) | Building, including associated objects or structures, listed under the Planning (Listed Buildings and Conservation Areas) Act 1990. Primarily under the responsibility of local authorities. |
| | Grade I | Buildings of “exceptional interest [representing] about one percent of the listed buildings” (Ashurst, N. 1994b: 12) |
| | Grade II* | Buildings “of special interest and considered to be worthy of preservation” (Ashurst, N. 1994b: 12) |
| | Grade II | Includes “(1) All structures not classified as Grade I or Grade II* but which were built prior to 1700 and survive in anything like the original condition and (2) most buildings built between 1700 and 1840” (Ashurst, N. 1994b: 12) |
| | ‘Conservation area’ | Areas "of special architectural or historic interest, the character or appearance of which it is desirable to preserve or enhance” (*Planning (Listed Buildings and Conservation Areas) Act 1990* 1990, s69). To be designated by local |

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| | | planning authorities. |
| The Nether-lands | Rijksmonument (‘national monument’) | Includes structures, or sites or archaeological monuments including such structures, “of at least 50 years of age which are of public interest because of their beauty, their importance to science or their cultural and historical value” (*Monumentenwet - Monuments and Historic Buildings Act* 1988/2011, Chapter 1) |
| | Provinciaal monument (‘provincial monument’) | Monuments and historic buildings “designated by the Provincial Executive in each [Dutch] province” (CHAN 2015) |
| | Gemeentelijk monument (‘municipal monument’) | Monuments and historic buildings of “local or regional importance” (CHAN 2015) |
| | ‘Urban and Village Conservation Area’ | “Groups of immovable objects which are of public interest because of their beauty, their spatial and structural coherence or their scientific and cultural/historical value and one or more historic buildings” (*Monumentenwet - Monuments and Historic Buildings Act* 1988/2011: Chapter 1) |
| Brazil | Historic and Artistic Heritage<br>May be listed as: | “all the movable and immovable objects existing in the country and whose conservation is of public interest, either because of their connection to memorable events in the history of Brazil or for their exceptional archaeological or ethnographical, bibliographic or artistic value” (*Decreto-lei 25/37* 1937)<br>Objects may be listed in one of the following categories: Archaeological, Ethnographic and Landscape; Historic; Fine Arts; Applied Arts. |
| | National interest object | Listed by the Institute for National Historic and Artistic Heritage (IPHAN) |
| | State interest object | Listed by state councils for heritage preservation. |
| | Municipal interest object | Listed by city councils for heritage preservation. |
| UNESCO | World Heritage Property[(2)] | For “cultural and natural heritage”, as defined by the World Heritage Convention, holding “Outstanding Universal Value, [i.e.] cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole.” (UNESCO 2015: par.49) |

Notes:
[(1)] All groups have further subcategories; overlaps, i.e., structures both scheduled and listed, may occur.
[(2)] Because it is legally binding, the UNESCO distinction works as an added level of protection in every country signing the Convention.

# Appendix C: Systems for the selection and/or assessment of built heritage cleaning methods

**Table C.0.1:** Systems for the selection and/or assessment of built heritage cleaning methods.

| Who | Criteria/parameters | Assessment method | Requirements |
|---|---|---|---|
| (Spry, quoted in Ashurst, N. 1994a) | **Index of masonry resistance to damage: $I_R$** Classifies the ability of various masonry materials to withstand cleaning damage | How: ratings between 0 and 10 are proposed for each index, e.g.: • Lime render: $0<I_R<2$ • Soft marble: $4<I_R<6$ • Hard sandstone: $6<I_R<8$ | "Select $I_C$ based on $I_T$ such as $I_S$ does not exceed $I_R$" (Spry, quoted in Ashurst, N. 1994a: 5) |
| | **Index of soiling tenacity: $I_T$** Classifies the degree of difficulty in soiling removal. | • Fungi, algae: $0<I_T<2$ • Soft urban grime: $2<I_T<4$ • Hard black gypsum crusts: $6<I_T<8$ | |
| | **Index of severity of the cleaning method: $I_S$** Classifies the damage potential of different cleaning methods | • Organic solvents: $0<I_S<2$ • Wet sand blasting: $6<I_S<8$ • Dry sand blasting: $8<I_S<10$ | |
| | **Index of cleaning ability of the method: $I_C$** Classifies the efficacy of the cleaning method | • Organic solvents: $2<I_C<4$ • Wet sand blasting: $8<I_C<10$ • Dry sand blasting: $8<I_C<10$ When: before cleaning | |
| (Laurenzi Tabasso & Mecchi 1985) (chemical cleaning) | **Medium surface roughness** ($R_a$)[(1)] "to check if the cleaning treatment produced any increase in the surface discontinuities" (1985: 978) | How: surface profilometer When: before and after cleaning | – |
| | **Water soluble salt content** "to check if soluble salts remained in the stone samples as a consequence of the cleaning treatment" (1985: 978) | How: conductivity measurements When: after cleaning | – |
| | **Capillary water absorption** (including capillarity coefficient and the asymptotic values of water absorption per unit surface) | How: following the NorMaL 11/83 standard Where: in treated and untreated surfaces. | – |
| (Werner 1989) | **Colour** one of the three "decisive parameters to describe the cleaning effect" (1989: 691) | How: following DIN 5033 and DIN 55891; CIELAB colour space When: before and after cleaning | – |

| Who | Criteria/parameters | Assessment method | Requirements |
|---|---|---|---|
| | **Roughness**<br>(as a "measure of the loss of substance" (1989: 691) | How: following DIN 4768<br>When: before and after cleaning | – |
| | **Capillary water absorption**<br>A "measure of the opening of the pores" (1989: 691); considered important because of the often required post-cleaning application of consolidants. | How : following DIN 52615 or using the Karsten tube method<br>When: before and after cleaning | – |
| (Biscontin, Zendri, Bakolas, Longega, et al. 1995) | • **Morphology**<br>• **Surface hardness**<br>• **Roughness**<br>• **Water soluble salt content**<br>• **Colour**<br>• **Porosity** | How: not specified<br>When: before, during and after cleaning – to understand surface behaviour over time, so that acceptability thresholds can be proposed. | "systems that do not promote the stability of the fabric, i.e., that degrade the materials, directly or potentially, for example by augmenting the specific surface and consequently its reactivity, should be excluded" (1995: 627) |
| (Alessandrini et al. 1995) | **Morphology** | How: SEM observation of samples<br>Remarks: analysis sensitivity depends on the surface finishing and morphological and physical characteristics of the substrates; improved for more polished surfaces.<br>When: before and after cleaning. | Authors conclude that it was not possible to obtain a numerical/quantitative expression of 'harmfulness'. |
| | **Mass loss** | How: Weighing of the dry unweathered sample on a precision scale<br>Remarks: test sensitivity varies with the mineralogical-petrographic and physical characteristics of the substrates; only found satisfactory for less compact substrates.<br>When: before and after cleaning. | |
| | **Capillary water absorption** | How: following NorMaL 11/85<br>Remarks: test sensitivity varies with the physical characteristics of the substrates; only found satisfactory for low porosity substrates; presence of clay minerals may also cause interference.<br>When: before and after cleaning. | |

| Who | Criteria/parameters | Assessment method | Requirements |
|---|---|---|---|
| (Sasse & Snethlage 1997) | **Visual appearance** | How: magnifying glass or microscope<br>When: after cleaning. | – |
| | **Colour** | How: colorimeter standard assessment (DIN 5033, part 3; DIN 6174).<br>When: after cleaning | Acceptability requirement: ΔE≤3 within one ashlar. |
| | **Roughness**<br>(parameters [(2)]: $R_{max}$; $R_a$; $R_z$; $P_c$.) | How: standard assessment: E DIN 4760 ff; E DIN 4770 ff; surface roughness meter<br>When: after cleaning | Acceptability requirement: average values for treated stone similar to those of the unweathered stone ("measured on the back side of sufficiently deep drill cores from the object or on freshly quarried stone samples" (1997: 226) |
| | **Water uptake coefficient** | How: standard assessment with Karsten tube<br>When: after cleaning | |
| | **Water vapour diffusion resistance** | How: standard assessment (DIN 52615)<br>When: after cleaning | |
| | **Biological colonization** (efficacy) | How: Most Probable Number test<br>When: after cleaning | – |
| (Vergès-Belmin 1996) | **Visual appearance**<br>(to inspect 'aesthetics', 'colour', 'homogeneity of the soil removal', 'cleanliness', 'conservation of the noble patina', and 'physical harmfulness') | How:<br>• naked eye observation;<br>• stereo microscope with a 5x to 80x magnification and/or video-cameras with up to 120x magnifications.<br>When: after cleaning; to repeat after one year. | Results to be judged by a group of experts. |
| | **Surface hardness**<br>(to inspect 'physical harmfulness' and 'conservation of the noble patina') | How:<br>• standard (RILEM) tests of scratch (Martens sclerometer);<br>• penetration and/or rebound hardness (Schmidt hammer).<br>When: after cleaning; to repeat after one year | – |
| | **Morphology** | How: SEM-EDS; petrography<br>When: after cleaning | – |
| | **Roughness**<br>(to inspect 'physical harmfulness' and 'conservation of the noble patina') | How:<br>• touch;<br>• stereo microscope observation of silicone cast of the cleaned surface and/or roughness quantification with tracking or scanning methods on the cast<br>When: after cleaning; to repeat after one year | – |
| | **Mass loss**<br>(to inspect 'physical harmfulness', 'conservation of the noble patina' and 'durability') | How:<br>• measured by sample weighing<br>• and/or in-depth measurements using the Hoffman and Heuser method.<br>When: after cleaning | – |

| Who | Criteria/parameters | Assessment method | Requirements |
|---|---|---|---|
| | **Water soluble salt content** | How:<br>• following chemical cleaning: salt identification with XRD and salt quantification using ion chromatography (IC), inductively coupled plasma emission spectrometry (ICP) or atomic absorption spectrometry (AAS).<br>• for monitoring salts removal: conductivity measurements<br>When: after cleaning | – |
| | **Chemical harmfulness** | How: pH measurements for monitoring neutralization of cleaning agents.<br>When: after cleaning | – |
| | **Colour** | How:<br>• standard measurement to "quantify visual impressions" (1996: 75) and/or be used for future reference;<br>• naked eye and/or stereomicroscope observation.<br>When: after cleaning | – |
| | **Water absorption under low pressure**<br>(assessment of 'conservation of the noble patina', 'durability' and 'homogeneity of the soil removal') | How: standard (RILEM) assessment with Karsten tube and/or microdrops;<br>When: after cleaning; to repeat after one year | – |
| | **Water vapour transfers** ('conservation of the noble patina' and 'durability' assessments); "useful […] when the question is not «How should we clean it?» but «Should we clean it or not?»" (1996: 71) | How: using RILEM or DIN standards;<br>When: after cleaning | – |
| | **Substrate and/or deposit characterization**<br>(type of materials; nature of binding materials; texture of the stone; nature of the soiling; former treatments) | How: XRD, IR spectrometry, petrography, black field OM and SEM-EDS.<br>When: before cleaning | – |
| (Delgado Rodrigues et al. 1997) | **Substrate and deposit characterization**<br>(for proposing cleaning recommendations) | How:<br>• for substrate characterization: petrography; porosity determination; ultrasonic velocity and water absorption measurements; decay depth; colour characterization and soluble salt content;<br>• for the deposits characterization: determination of thickness, cohesion and salt content; colour measurements; chemical identification of major components<br>When: before cleaning | – |

| Who | Criteria/parameters | Assessment method | Requirements |
|---|---|---|---|
| | **Reference surface(s)**<br>(intended cleaning level, corresponding to the surface(s) found "most appropriate for the final state of the object" (1997: 339); identified after substrate and deposit characterization, visual inspection and cleaning trials) | How:<br>• cleaning methods specified;<br>• surface characterization using quantifiable parameters (to be subsequently used as control parameters);<br>• documented;<br>• duly agreed between all the actors: owner, contractor and scientific consultant(s).<br>• recommended reference parameters: colour; roughness and, when water methods are used, salt content.<br>When: research, negotiation and operational stages | Agreement with the reference surface in terms of visual appearance and verification of the pre-selected reference parameters |
| (Laurenzi Tabasso & Simon 2006) | **Visual appearance**<br>(to evaluate "loss of materials, rounding of edges, micro-fractures" (2006: 75)) | How:<br>• naked eye observation;<br>• magnifying lenses or field stereo microscope;<br>• photography and macro-photography.<br>When: before and after cleaning | 'Positive evaluation': "no increase in micro-fractures and other surface discontinuities." (2006: 75) |
| | **Microscopic assessment**<br>(to evaluate "roughness (qualitatively), porosity, loss of material, grain destruction" (2006: 75)) | How: OM and SEM-EDS on cross-sections<br>When: before and after cleaning | |
| | **Colour**<br>(for immediate assessment and long-term monitoring) | How: Reflectance spectrophotometer (NorMaL 43/93), colour atlases.<br>When: before and after cleaning | 'Positive evaluation' "criteria to be defined case-by-case." (2006: 75) |
| | **Surface roughness**<br>(including: roughness depth (Ra, Rx, Rmax); number of peaks > x µm (P) (1) | How: Stylus profilometer (DIN 4762, 4768, 4772, E-DIN 4760, 4770), directly or through surface casts;<br>When: before and after cleaning | 'Positive evaluation': "no increase in roughness, micro-fractures and other surface discontinuities." (2006: 75) |
| | **Capillary water uptake under low pressure**<br>Parameters: W-value<br>"Useful when testing products on lab samples and for long-term monitoring." (2006: 75). | How: Karsten tube (RILEM II.6, EN-ISO 15148, NORMAL 44/93)<br>When: before and after cleaning | 'Positive evaluation': "No increase in absorbed water with reference to the weathered but not sooted stone" (2006: 75). |
| | **Water vapour permeability**<br>"Useful when testing products on lab samples" (2006: 75) | How: measured on drill core slices (NorMaL 21/85, RILEM 25-PEM II.2)<br>When: before and after cleaning | 'Positive evaluation': "No variation of permeability with reference to the weathered but not sooted stone" (2006: 75) |
| | **Water vapour diffusion resistance**<br>parameters: Δ-value and sd-value on drill core slices. | How: standard assessment using: EN-ISO 12572:2001; DIN 52615:1987; wet cup (dry cup);<br>When: before and after cleaning | |

| Who | Criteria/parameters | Assessment method | Requirements |
|---|---|---|---|
| | **Salt profile**<br>(profiling of $Na^{+}$, $K^{+}$, $Ca^{2+}$, $Mg^{2+}$, $SO_4^{2-}$, $NO^{2-}$, $NO^{3-}$, $Cl^{-}$) | How: surface and in-depth profiles (UNI 11087:2003), using drill powder or salt extraction with absorbing compresses<br>When: before and after cleaning | 'Positive evaluation': "strong reduction of salt content" (2006: 75) |
| (UNI 2006) (for laser cleaning) | **Visual appearance**<br>(for the definition of laser thresholds) | How: Laser cleaning should be tested on site, with increasing energies on $5mm^2$ areas.<br>Result validation by macro- and micro-observation (e.g. with a 30x portable microscope), accompanied by photographic documentation.<br>When: before and during cleaning tests, to define ablation thresholds | No discolouration or ablation of the target surface |
| | **Microscopic observation**<br>(if visual appearance is insufficient) | How: OM and SEM observations at surface level and in cross-sections.<br>When: before and during cleaning tests, to define ablation thresholds | |
| (Hauff et al. 2008) | **Cleaning test panels**<br>(for the pre-selection of cleaning methods for further testing)<br>Assessed parameters:<br>• 'cleaning degree': classifiable in a 4-point scale between "no visible patina" and "no cleaning effect" (2008: 383)<br>• 'homogeneity degree': classifiable in a 4-point scale between "homogenous" and "very inhomogeneous" (2008: 384) | How: the parameters are evaluated by macroscopic observation by an expert panel including all the relevant intervention actors<br>When: after the cleaning tests | Acceptability criteria: only methods obtaining a "cleaning degree 2" ("slightly visible patina") and a "homogeneity degree 1" ("homogenous") (2008: 384) should be selected for further assessment |
| | '**Intactness of the cleaned surface'**<br>"especially sensitive areas" (2008: 384) should be identified and documented for damage assessment by image comparisons before and after cleaning. | How: transportable digital microscope allowing for systematic photographic records (instead of SEM)<br>When: before and after cleaning | – |
| | **Water soluble salt content**<br>(mandatory for chemical cleaning) | How: eluate analysis of desalination poultices by IR-spectroscopy or photometric methods<br>When: after cleaning | – |
| | **Water absorption under low pressure** | How: Karsten tube or the micro-drop absorption time<br>When: before and after cleaning | – |
| | **Air permeation measurement**<br>(instead of water vapour diffusion resistance, to avoid sampling) | How: device apt for on-site use<br>When: before and after cleaning | – |
| | **Cost**<br>(considered a not decisive but important criterion) | How: by considering the necessary working time and equipment and material costs.<br>When: before the intervention | – |

| Who | Criteria/parameters | Assessment method | Requirements |
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| (Delegou et al. 2012; Delegou & Moropoulou 2008; Moropoulou et al. 2008) (for black crusts on marble surfaces) | **‘Patina preservation index’** (%) (PPI) | How: Analysis of chemical and mineralogical composition changes at surface level via SEM-EDS<br>When: before and after cleaning | ‘Accepted result’ [(2)]: ‘Low’: between 0% < PPI < 70% |
| | **‘Ratio of actual to projected surface area’** (r)<br>“This ratio is a geometrical descriptor of a surface and has a very close relation with some functional properties of surfaces like wear”(Moropoulou et al. 2008: 1277) | How: micro-topographic assessment of changes via LP<br>When: before and after cleaning | ‘Accepted result’[(2)]: ‘Medium’: 1.25 < r < 3 |
| | **Roughness** (Rq) [(1)] | How: LP following the BS EN ISO 4288:1988 standard<br>When: before and after cleaning | ‘Accepted result’[(2)]: ‘Medium’: 5μm < Rq < 20μm. |
| | **‘Fracture density’** (%) (FD) | How: via DIP of SEM images at near surface level, measured in cross-sections<br>When: before and after cleaning | ‘Accepted result’[(2)]: ‘Medium’: 8%< FD < 25% |
| | **Colour**<br>(to assess ‘aesthetics’ and ‘black deposits removal degree’) | How: colorimeter measurements<br>When: before and after cleaning | ‘Accepted result’[(2)]: ‘Medium’ = 5 < ΔE < 15 |
| | **‘Preservation index of gypsum layer’** (%) (PIGy)<br>(thickness of the micro-crystalline gypsum layer) | How: chemical and mineralogical composition changes at surface level measured via SEM-EDS analysis<br>When: before and after cleaning; | ‘Accepted result’[(2)]: ‘High’: 50% < PIGy < 100% |
| (Fraum et al. 1995) [(3)] | **Surface morphology**<br>(assessment of superficial changes induced by cleaning) | How: SEM and OM observations<br>When: before and after cleaning | – |
| (Iglesias et al. 2006) [(3)] (mechanical cleaning) | “**Surface abrasion**” (2006: 685) | How: naked eye observations, stereoscopic magnifying glass and SEM<br>When: before and after cleaning | – |
| | **Polychromy and deposits analysis**<br>(to assess damage and cleaning efficacy) | How: SEM-EDS<br>When: before and after cleaning | – |
| (Álvarez de Buergo et al. 2013) [(3)] (laser cleaning) | **Surface morphology**<br>(surface damage assessment following laser cleaning) | How: SEM-EDS-SE<br>When: before and after cleaning | – |
| | **Roughness**<br>(parameter[(1)]: $R_z$) | How: optical surface roughness meter<br>When: before and after cleaning | – |
| | **Colour** | How: colorimetric measurements<br>When: before and after cleaning | – |

| Who | Criteria/parameters | Assessment method | Requirements |
|---|---|---|---|
| (Ďoubal 2014) [3] | **Visual appearance**<br>(for pre-selecting the most effectively and less harmfully cleaned surfaces for further assessment) | How:<br>• naked-eye,<br>• macro-photographic<br>• stereo-magnifier and<br>• optical microscopy<br>When: after cleaning | – |
| | **Surface morphology** | How: SEM observation<br>When: after cleaning | – |
| | **Water absorption under low pressure** | How: Karsten tube<br>When: after cleaning, for comparison with uncleaned samples | A value increase is desirable. |
| | **Composition of soiled and clean surfaces**:<br>“the mode of deposition of the soiling and the condition of the substrate immediately under the soiled layer clearly play an essential role in the cleaning process” (2014: 129). | How: SEM-EDS analysis<br>When: before and after cleaning | |

Notes:

(1) Roughness parameters:

- Amplitude parameters – describe vertical deviations of the roughness profile from a (previously calculated) mean line:
  - $R_{max}$ (µm): maximum roughness
  - $R_a$ (µm): arithmetic average of absolute values of the (filtered) roughness profile
  - $R_z$ (µm): “arithmetic mean value of the sum of the height of the 5 tallest peaks and the depth of the 5 lowest valleys.” (Álvarez de Buergo et al. 2013: 174)
  - $R_q$: root mean square of the (filtered) roughness profile
- $P_c$: “number of registered peaks > *x* µm: the height *x* of the peaks must be defined for each material” (Sasse & Snethlage 1997: 226) (obtained from the unfiltered profile)

(2) This ‘Accepted result’ is not a requirement per se: each criterion is an input on a 6-criteria fuzzy classification expert system that returns a ‘Cleaning Performance Index’ (CPI), following ‘fuzzy rules’ based on expert opinion, experimental results in black crust cleaning in marbles and relevant literature. The criticality and influence of each criterion in the CPI were not specified in any of the consulted sources. The CPI is a value between 1 and 10, and only methods with a classification above 7 are acceptable (Delegou et al. 2012; Delegou & Moropoulou 2008; Moropoulou et al. 2008).

(3) Authors not specifically proposing an assessment system

# Appendix D: Summary report of the Delphi exercise

## *First round*

### Document 1: Proposal of a procedure for the planning of stone heritage cleaning interventions

**Introduction**
Thank you for agreeing to participate in this research on stone heritage cleaning compatibility.
This study is being carried out in the context of a PhD dissertation in Conservation Sciences dedicated to the application of the compatibility concept to conservation interventions planning.
In this context, compatibility is defined as non-harmfulness in the short and long run towards the current and anticipated significance of the heritage object; significance is defined as the sum of all the values that are attached to the object by social groups in a given moment of time and space.

The objective of the present procedure specifically concerns stone heritage cleaning interventions – the ultimate goal of this study is to propose a support tool for the planning of heritage-compatible cleaning interventions. Potential users include planners who are in charge of preparing intervention projects but who may be less knowledgeable about the technical aspects involved in stone heritage cleaning or that might find useful to resort to a systematized procedure.
It was considered that a compatibility assessment may be likened to an incompatibility risk assessment, given that its goals are the identification, analysis and characterization of sources, mechanisms and consequences of damage, with its mitigation in view. Therefore, a procedure draft was designed departing from a risk analysis of heritage stone cleaning. Using the tool should permit the planner to understand which incompatibility risks are involved in the use of a given cleaning method on the heritage object, as well as to compare different methods and, eventually, to obtain some insights on how to reduce those risks. Please note that this analysis presupposes the efficacy of the cleaning methods, which is not contemplated here.

The goal of this inquiry is to have your expert opinion on the proposed support tool, which is briefly described below. The questionnaire proper was sent to you together with the current document, as a word document labelled 'DelphiQuestionnaire'; please edit it by adding your opinions after you have read the description below.

**Procedure for the risk assessment of stone heritage cleaning**
The idea behind this risk assessment procedure is to provide the planning of stone heritage cleaning with a tool of straightforward usage that nevertheless encompasses the complexity of the issues involved.
Please note that the method described below does not allow for deciding whether or not to clean. The intention of cleaning is presupposed and the method concerns uniquely the planning phase. Even if the planner concludes that the risk is too high, there is no form of comparing results with the non-cleaning

option (this would require analysing the impact of different deposits on the significance and on the material condition of the object.)

The procedure intends to assess the compatibility risks that different cleaning methods may present to the significance of a given heritage object. In this context, the main identified incompatibility risks are: mass loss; discolouration; indirect damage (e.g. caused by clay swelling, infiltrations, etc).

These risks are assessed via the semi-quantitative evaluation of the following factor classes: the vulnerability of the object, the aggressiveness of the cleaning method, the synergistic effects that may occur with method/substrate combinations, leading to a risk increment, and the consequences of damage occurring during cleaning; these assessments should permit the planner to obtain an insight on the level of risk involved.

Evaluation scales were used that vary according to the need for distinguishing between the different parameters used for the assessment of factors: vulnerability and consequences have their parameters rate between 1 (lower risk) and 5 (higher risk), whereas for the aggressiveness parameters it was found that classifications between 1 (lower risk) and 10 (higher risk) would allow for a more accurate appraisal of the different methods; finally, the synergies are considered as risk increments that should be classified between 1 (minimum increment) and 2 (maximum increment). In the end, the aggregation of the different factors is achieved via a simple multiplication, to give an idea of the risk level involved. Please note that the attribution of different scales to the different factors may be considered as a weighing of these factors.

The ratings proposed for each factor are presented below.

First, the vulnerability of the stone should be rated. This rating intends to mirror the differences between stone types that objectively cause them to be more or less resistant and capable of withstanding cleaning actions.

**A. Vulnerability** should be rated according to substrate type and conservation condition; for any given substrate, its susceptibility to damage increases with the seriousness of decay.

| Vulnerability<br>Substrate | Ratings (1 – 2 – 3 – 4 – 5) |
|---|---|
| Granites | 1–5 |
| Dense limestones (Porosity <5%) | 1–5 |
| Medium limestones (5%< Porosity <15%) | 3–5 |
| Very porous limestones (Porosity >15%) | 4–5 |
| Marbles | 1–5 |
| Dense sandstones (Porosity <5%) | 1–5 |
| Medium sandstones (5%< Porosity <15%) | 2–5 |
| Very porous sandstones (Porosity >15%) | 4–5 |
| Renders | 3–5 |

N.B.: The probability of damage increases with substrate decay: for each substrate type, lower values correspond to sound substrates and higher values should be chosen for decayed substrates. As an indication, the following decay stages may be considered:

- Surface with no significant signs of decay.
- Surface with minor signs of decay. Cracks may be present and incipient mass losses may happen.
- Surface with evident signs of decay and moderate mass losses (actual or potential). Detachment of scales, cracks and powdering may occur in significant areas of the unit.
- Surface with generalized degradation features and relevant mass losses (actual or potential).

The cleaning method is then ranked in terms of its aggressiveness, i.e., proneness to inflict damage regardless of the stone substrate where it is applied; the proposed assessment is described below.

**B. Aggressiveness** of each method should be rated according to the controllability it allows for a knowledgeable operator and the energy density applied on the substrate.

| Aggressiveness | Ratings |
|---|---|

| Method | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Mechanical** | | | | | | | | | | |
| Hand tools | ■ | ■ | ■ | ■ | | | | | | |
| Particle jet : - low density microparticles (<0.1mm) at low pressure (<0.5MPa) | | | | ■ | | | | | | |
| - intermediate values for pressure and particle size and density | | | | ■ | ■ | ■ | ■ | ■ | ■ | |
| - dense particles, sizes > 0.1mm, at high pressures (> 0.5MPa) | | | | | | | | | | ■ |
| Microhammer/pneumatic tools | | | | ■ | ■ | ■ | | | | |
| **Chemical** | | | | | | | | | | |
| Neutral reagents | ■ | ■ | | | | | | | | |
| Weakly acidic or alkaline reagents | | | ■ | ■ | ■ | | | | | |
| Strongly acidic or alkaline reagents | | | | | | | | ■ | ■ | ■ |
| **Water-based** | | | | | | | | | | |
| Without pressure (mist, poultices), with or without brushing | ■ | ■ | ■ | | | | | | | |
| Water jet: - low pressures (~0.2MPa – 0.3MPa) | | | ■ | ■ | ■ | | | | | |
| - intermediate values | | | | | ■ | ■ | ■ | | | |
| - high pressures (>0.5MPa) | | | | | | | | | ■ | ■ |
| Wet grit blasting | | | | | | | | | | ■ |
| **Laser** | | | | | | | | | | |
| Below ablation threshold | ■ | | | | | | | | | |
| Above ablation threshold | | | | | | | | | | ■ |

N.B.:
- The likelihood of damage decreases with the controllability of the method and increases with the density of the energy applied. Higher values should be chosen for methods that are increasingly more difficult to control and/or that are applying more intense energy densities (e.g. larger or denser or more irregular particles, higher pressures, smaller nozzle diameters; higher or lower pH values, etc).
- Methods must be considered alone; if planning to use a combination of methods, two separate assessments are required.

Once the absolute vulnerability of the stone and the absolute aggressiveness of the method are evaluated, it is necessary to analyse the synergistic effects that may arise from different substrate/method combinations. Indeed, some features of a given stone may cause it to be more or less harmed depending on the method used. For instance, a salt laden wall may be seriously affected by a water-based method, whereas a purely mechanical method would cause no damage increment in that particular regard. It was considered that these synergies have a risk amplification effect and therefore should be rated between 1 and 2. The table below lists the proposed risk ratings to evaluate these interactions.

**C. Synergies** may occur whenever there is reactiveness between the substrate and the cleaning method

| Synergies | Increments | |
|---|---|---|
| Methods | 1 | 2 |
| **Chemical** | | |
| Reactive with the substrate | ■ | ■ |
| **Water-based** | | |
| Highly absorbent/permeable construction materials<br>Substrates with soluble salts | ■ | ■ |

| | | | | | |
|---|---|---|---|---|---|
| Substrates with clay minerals<br>Marbles when using steam<br>Environmental freezing temperatures | | | | | |
| Laser | | | | | |
| Coloured substrates | | | | | |

N.B.:
- The probability of damage increases with both reactiveness and contact time between substrate and cleaning agent.
- Mechanical methods were found not to have any particular synergistic effect with the substrate, and therefore, for these methods, synergy factor C=1.

Finally, the seriousness of the consequences of damage occurring during cleaning should be assessed; this means asking: "How much would the damage of the surface material affect the significance of the object?", i.e., "How relevant is the surface in the overall significance of the object?" Notwithstanding the necessity of a lengthier analysis beforehand, it is proposed that this assessment may be based on the following table:

**D. Impact on significance**: assessing the consequences of damage.

| Impact on significance | Ratings | | | | |
|---|---|---|---|---|---|
| Surface relevance | 1 | 2 | 3 | 4 | 5 |
| Listed objects | | | | | |
| Surfaces of little relevance | | | | | |
| Relevant surfaces | | | | | |
| Unlisted objects | | | | | |
| Surfaces of little relevance | | | | | |
| Relevant surfaces | | | | | |

N.B.: the seriousness of damage consequences increases with the relevancy of the surface materials for the overall significance of the object.

**Getting a risk estimate**

Risk equals the product of probability and consequences of damage occurring. In this analysis, factors A, B and C are related to the likelihood of damage occurring, whereas factor D assesses its consequences. The assessment of factors A through D should allow the planner to verify where a given object/cleaning method combination stands – qualitatively – in terms of risk. It is proposed that the likelihood factors (A, B and C) are aggregated via a simple multiplication and that the obtained value is then crossed-checked with the consequence factor (D) in the following cleaning risk matrix:

**Cleaning Risk Matrix Proposal**

| Risk | | Consequences (D) | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 |
| Likelihood (AxBxC) | 50-100 | Very high | Very high | High | High | Medium |
| | 20-50 | Very high | High | High | Medium | Medium |
| | 10-20 | High | High | Medium | Low | Low |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 5-10 | High | Medium | Medium | Low | Very low |
| | 1-5 | Medium | Medium | Low | Very low | Very low |

Risks more serious than 'medium' should immediately prompt a more careful consideration of the cleaning method; reassessments with alternative methods should be tried to see if the risk involved can be lowered. There are, however, additional planning steps that may increase or decrease the risk of the cleaning operation, making them decisive for the final result.
Indeed, problems may arise due to planning omissions such as not requiring (i) the necessary operator training and/or experience; (ii) the supervision and active participation of conservator-restorers; (iii) a well-structured team with all the necessary means at their disposal. Of no less importance is the definition and characterization of a cleaning level (e.g. by means of a reference surface), agreed with the contractor; allowing an adequate period and budget for the intervention; and choosing adequately trained control professionals. Overseeing these topics is likely to cause over-cleaning (or, at best, under-cleaning); carefully planning for them, though, may in fact reduce the risks of the cleaning intervention.

The table below shows planning factors that may help configure an optimal intervention scenario or, quite the opposite, cause the whole intervention to irrevocably fail. Unlike the previously discussed factors, whose risk may be rated according to given features of the object or cleaning method, classifying the factors below depends on if and how they are planned. A careful and considered planning may reduce the risk values, whereas an ill-considered or absent planning may double or triple the cleaning risk involved.

| **Planning factors** |
|---|
| Preparatory [(1)] |
| Significance analysis |
| Deposit impact assessment |
| Defining, characterizing and justifying the cleaning level |
| Adequacy of time and budget constraints |
| |
| Required team skills [(2)] |
| Operators training and experience |
| Experienced conservator-restorers integrated in the organizing and execution teams |
| Adequacy of the tools and instruments available |
| Adequacy of the team structure |
| |
| Control [(3)] |
| Adequacy of the controlling methods |
| Adequacy of the controlling agents |

Notes:
[(1)] to know exactly what must and must not be removed is crucial; it entails not only a significance analysis, but also how the deposits impact on that significance, in the short and in the long run.
[(2)] requiring adequately trained and experienced professionals, including conservators-restorers in key organization and execution positions, and ensuring adequate means and team structures are all sine qua non conditions for accomplished cleaning interventions.
[(3)] a well defined and characterized cleaning level that will aptly function as a control tool, and was previously agreed with the contractor; as well as adequately trained control professionals, are essential for a satisfactory result.

Adequately planning for all the aspects mentioned in the previous table might reduce the risks, but will not, however, eliminate them altogether. Conversely, not planning for these aspects might easily cause a 'medium' risk to become 'high' or 'very high' and it is most likely to make cleaning risks unacceptable.

## Document 2: First Round Delphi Questionnaire

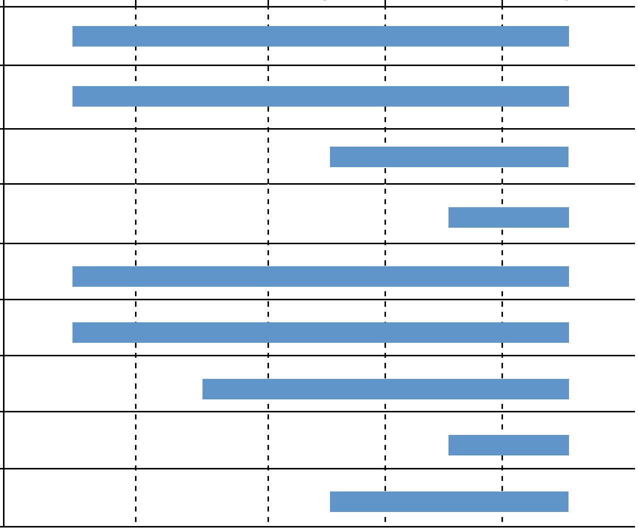
**Introduction to the Delphi Technique**
The Delphi technique is a method that structures group communication in a way that allows for the group to effectively tackle a complex problem. The process starts with the experts answering a questionnaire (below); the answers are then summarized and submitted to the panel, so that the different (anonymous) appreciations may be re-evaluated. Successive iterations allow for consensus to be reached without group or peer pressure, and all answers are given equal importance. More than that, this technique allows establishing a debate between various professionals without their physical presence being required, which is a plus in the case of a panel comprising experts from different nationalities.
The different contributions will be summarized by me and the experts' names will remain anonymous. If you have any questions about any of these procedures, please contact me by email to mjrevez@lnec.pt.

The purpose of this Delphi process is to evaluate the structure and to calibrate the parameters of the procedure described in the pdf file labelled 'Cleaning_risks_assessment' sent to you together with the current document. Expert appreciation is needed regarding both the factor classes (A through D) and the parameters chosen to evaluate them; as well as regarding the risk reduction options, here presented as 'planning factors'.
Please bear in mind that justifications of your opinions are extremely valuable, so that the remainder of the Delphi panellists may better understand and discuss your views.

**Questionnaire**

**1. Factor A: Vulnerability**
**Vulnerability** should be rated according to substrate type and conservation condition; for any given substrate, its susceptibility to damage increases with the seriousness of decay.

| Vulnerability | Ratings | | | | |
|---|---|---|---|---|---|
| Substrate | 1 | 2 | 3 | 4 | 5 |
| Granites | | | | | |
| Dense limestones (Porosity <5%) | | | | | |
| Medium limestones (5%< Porosity <15%) | | | | | |
| Very porous limestones (Porosity >15%) | | | | | |
| Marbles | | | | | |
| Dense sandstones (Porosity <5%) | | | | | |
| Medium sandstones (5%< Porosity <15%) | | | | | |
| Very porous sandstones (Porosity >15%) | | | | | |
| Renders | | | | | |



N.B.: The probability of damage increases with substrate decay: for each substrate type, lower values correspond to sound substrates and higher values should be chosen for decayed substrates. As an indication, the following decay stages may be considered:
- Surface with no significant signs of decay.
- Surface with minor signs of decay. Cracks may be present and incipient mass losses may happen.
- Surface with evident signs of decay and moderate mass losses (actual or potential). Detachment of scales, cracks and powdering may occur in significant areas of the unit.
- Surface with generalized degradation features and relevant mass losses (actual or potential).

**Questions**

1.a) Do you agree with the assessment scheme for this factor: different substrates ranked according to their conservation condition? If not, how would you assess the Vulnerability factor? Why?

1.b) Do you agree with the substrates chosen? Would you add or remove a substrate? Why?

1.c) Do you agree with the suggested porosity limits? If not, which ones do you suggest? Why?

1.d) Do you agree with the proposed rating ranges? If not, which ranges would you propose? Why?

1.e) Do you have any additional comments pertaining to this section?

## 2. Factor B: Aggressiveness

**Aggressiveness** of each method should be rated according to the controllability it allows for a knowledgeable operator and the energy density applied on the substrate.

| Aggressiveness | Ratings | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Method | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **Mechanical** | | | | | | | | | | |
| Hand tools | ■ | ■ | ■ | ■ | | | | | | |
| Particle jet :<br>- low density microparticles (<0.1mm) at low pressure (<0.5MPa) | | | | ■ | | | | | | |
| - intermediate values for pressure and particle size and density | | | | ■ | ■ | ■ | ■ | ■ | ■ | |
| - dense particles, sizes > 0.1mm, at high pressures (> 0.5MPa) | | | | | | | | | | ■ |
| Microhammer/pneumatic tools | | | | ■ | ■ | ■ | | | | |
| **Chemical** | | | | | | | | | | |
| Neutral reagents | ■ | | | | | | | | | |
| Weakly acidic or alkaline reagents | | | ■ | ■ | ■ | | | | | |
| Strongly acidic or alkaline reagents | | | | | | | | ■ | ■ | ■ |
| **Water-based** | | | | | | | | | | |
| Without pressure (mist, poultices), with or without brushing | ■ | ■ | ■ | | | | | | | |
| Water jet:<br>- low pressures (~0.2MPa – 0.3MPa) | | | ■ | ■ | ■ | | | | | |
| - intermediate values | | | | | ■ | ■ | ■ | | | |
| - high pressures (>0.5MPa) | | | | | | | | | ■ | ■ |
| Wet grit blasting | | | | | | | | | | ■ |
| **Laser** | | | | | | | | | | |
| Below ablation threshold | ■ | | | | | | | | | |
| Above ablation threshold | | | | | | | | | | ■ |

N.B.:
- The likelihood of damage decreases with the controllability of the method and increases with the density of the energy applied. Higher values should be chosen for methods that are increasingly more difficult to control and/or that are applying more intense energy densities (e.g. larger or denser or more irregular particles, higher pressures, smaller nozzle diameters; higher or lower pH values, etc).
- Methods must be considered alone; if planning to use a combination of methods, two separate assessments are required.

**Questions**

2.a) Do you agree with the assessment scheme: different methods ranked according to their controllability and energy density? If not, how would you assess the Aggressiveness factor? Why?

2.b) Do you agree with the method types chosen, as well as their respective subdivisions? Would you add or remove a method? Why?

2.c) Do you agree with the proposed rating ranges? If not, which ranges would you suggest? Why?

2.d) Do you have any additional comments pertaining to this section?

### 3. Factor C: Synergies

**Synergies** may occur whenever there is reactiveness between the substrate and the cleaning method

| Synergies | Increments | |
|---|---|---|
| Methods | 1 | 2 |
| Chemical | | |
| Reactive with the substrate | | |
| Water-based | | |
| Highly absorbent/permeable construction materials<br>Substrates with soluble salts<br>Substrates with clay minerals<br>Marbles when using steam<br>Environmental freezing temperatures | | |
| Laser | | |
| Coloured substrates | | |

N.B.:
- The probability of damage increases with both reactiveness and contact time between substrate and cleaning agent.
- Mechanical methods were found not to have any particular synergistic effect with the substrate, and therefore, for these methods, synergy factor C=1.

**Questions**

3.a) Do you agree with the assessment scheme: different methods ranked according to their reactiveness and contact time with the substrate? If not, how do you suggest this would be assessed? Why?

3.b) Do you agree with the evaluation parameters chosen? Would you add or remove a parameter? Why?

3.c) Do you agree with the proposed rating increments? If not, which increments would you suggest? Why?

3.d) Do you have any additional comments pertaining to this section?

### 4. Factor D: Impact on Significance

**Impact on significance**: assessing the consequences of damage.

| Impact on significance | Ratings | | | | |
|---|---|---|---|---|---|
| Surface relevance | 1 | 2 | 3 | 4 | 5 |
| Listed objects | | | | | |
| Surfaces of little relevance | | | | | |
| Relevant surfaces | | | | | |
| Unlisted objects | | | | | |
| Surfaces of little relevance | | | | | |
| Relevant surfaces | | | | | |

N.B.: the seriousness of damage consequences increases with the relevancy of the surface materials for the overall significance of the object.

**Questions**

4.a) Do you agree with the assessment scheme based on the relevance of the surface features to the overall significance? If not, how do you suggest this would be assessed? Why?

4.b) Do you agree that the overall significance of the object depends on it being listed or not? Would you group objects differently? How and why?

4.c) Do you agree with the proposed rating ranges? If not, which ranges would you suggest? Why?

4.d) Do you have any additional comments pertaining to this section?

**5. General appreciation of the chosen factors**

Considering all that described for the cleaning risk assessment factors – **Vulnerability, Aggressiveness, Synergies and Impact on significance**:

**Questions**

5.a) Do you agree with each one of these factors?

5.b) Would you remove any of the factors? Which one(s)? Why?

5.c) Would you add a different factor? Which one(s)? How would you assess it (them)? Why?

5.d) Do you agree with the different rating scales chosen for the different factors (e.g. Aggressiveness from 1 to 10; Synergies from 1 to 2)? If not, why?

5.e) Do you have any additional comments pertaining to this section?

**6. Cleaning risk matrix**

**Cleaning Risk Matrix Proposal**

| Risk | | Consequences (D) | | | | |
|---|---|---|---|---|---|---|
| | | 5 | 4 | 3 | 2 | 1 |
| Likelihood (AxBxC) | 50-100 | Very high | Very high | High | High | Medium |
| | 20-50 | Very high | High | High | Medium | Medium |
| | 10-20 | High | High | Medium | Low | Low |
| | 5-10 | High | Medium | Medium | Low | Very low |
| | 1-5 | Medium | Medium | Low | Very low | Very low |

**Questions**

6.a) Do you agree with the proposed zoning? If not, which zones would you alter? Why?

6.b) Do you have any additional comments pertaining to this section?

**7. Planning**

**Planning factors**

| |
|---|
| Preparatory [1] |
| Significance analysis |
| Deposit impact assessment |
| Defining, characterizing and justifying the cleaning level |
| Adequacy of time and budget constraints |
| |
| Required team skills [2] |
| Operators training and experience |
| Experienced conservator-restorers integrated in the organizing and execution teams |
| Adequacy of the tools and instruments available |
| Adequacy of the team structure |
| |
| Control [3] |
| Adequacy of the controlling methods |
| Adequacy of the controlling agents |

Notes:
(1) to know exactly what must and must not be removed is crucial; it entails not only a significance analysis, but also how the deposits impact on that significance, in the short and in the long run.
(2) requiring adequately trained and experienced professionals, including conservators-restorers in key organization and execution positions, and ensuring adequate means and team structures are all sine qua non conditions for accomplished cleaning interventions.
(3) a well defined and characterized cleaning level that will aptly function as a control tool, and was previously agreed with the contractor; as well as adequately trained control professionals, are essential for a satisfactory result.

**Questions**

7.a) Do you agree that the suggested planning parameters have a relevant impact in the risk of a heritage cleaning intervention?

7.b) Do the listed parameters cover every relevant aspect? Would you remove or add any parameters? Which ones and why?

7.c) Do you have any additional comments pertaining to this section?

Thank you very much for your collaboration.

## *Second Round*

### Document 3: First Round Results + Second Round Questionnaire

**How to proceed in this second round**

The first round of the Delphi questionnaire yielded 15 contributions from experts in different areas of stone heritage conservation. For this second round we have grouped the answers and identified all the points that deserve a new enquiry to reach the expected consensus. The document is organized as follows:

1. According to the structure of the **Procedure** and of the previous questionnaire, this document was divided into seven chapters or sections.
2. Each chapter has two parts: (i) the new version of the respective **Procedure** section and (ii) the Delphi debate for that section;
3. In the new version of the **Procedure**, edits resulting from the previous panel answers are marked in colour (red); the Delphi debate corresponds to the indented text typed *in italics*;
4. The Delphi debate for each section holds the new interaction with the panel members. It contains the discussion around that section, explains the adjustments and corrections (in red) made to the **Procedure** and asks the second round questions.
5. The questions, presented in small tables for easy identification, are yes/no questions; if choosing no, please explain why, so that the other members may understand your reasoning or, if applicable, give an alternative.
6. Please bear in mind that the text *in italics* is for your information only and will not be included in the final version of the assessment **Procedure**, but all text in regular type is to become a part of the **Procedure** (pending of course the panel consensus).

We opted to rule consensus as an acceptance by at least 80% of the panellists, i.e. 12 panellists. This means that, for each question, 12 ‘yes’ answers will validate that specific issue.

Once again, thank you very much for your collaboration
Maria João Revez
mjoaorevez@gmail.com

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**Built Heritage Cleaning Incompatibility Risk Assessment Procedure**

**Assessment Procedure – Introduction**

Whenever deposits are believed to be actually or potentially damaging to the significance of a given heritage object, and/or when necessary conservation treatments call for a deposit removal, a cleaning intervention may be decided upon. One of the most determining factors in this decision is whether or not the risk of cleaning outweighs its benefits. While the overwhelming variety of possible combinations between objects, deposits and environmental conditions precludes a deposit risk assessment procedure to be designed, a cleaning risk assessment may provide helpful guidelines on how to proceed in choosing and planning the less harmful way of removing the undesirable deposits.

The idea behind this risk assessment procedure is to provide the planning of stone heritage cleaning with a tool of straightforward usage that nevertheless encompasses the complexity of the issues involved.
Please note that the procedure described below does not allow for deciding whether or not to clean. The intention of cleaning is presupposed and the procedure concerns uniquely its planning phase. Even if the planner concludes that the risk is too high, there is no form of comparing the results with the non-cleaning option (this would require analysing the impact of different deposits on the significance and on the material condition of the object.)

The effectiveness of the cleaning method in deposit removal is also presupposed. The idea is that, given the deposits and the target surface, a group of cleaning methods is chosen which can then be assessed in terms of cleaning compatibility by using the current procedure.
The objective of this methodology is the assessment of the risks that a cleaning intervention may present to the significance of a given heritage object, and so it presupposes that the effectiveness of the method(s) has previously been established. This risk assessment aims at providing some planning guidelines on how to choose the less incompatible option. Therefore, it is largely about harmfulness, and not about effectiveness. In this context, the main identified incompatibility risks (or incompatibility damage) are: (i) undesirable mass loss; (ii) discolouration; (iii) indirect damage (e.g. caused by clay swelling, infiltrations, etc).

Risk is defined as the multiplication of the likelihood of damage occurring and the consequences of that occurrence; in this case:

$$Incompatibility\ Risk\ (IR) = Likelihood\ of\ damage \times consequences\ of\ damage$$

There are several factors of risk in a heritage cleaning intervention, influencing both classes in the equation above. For the current procedure, these factors were divided into 'hard' and 'soft': the 'hard' factors correspond to items that may be parameterized and semi-quantitatively evaluated, whereas the 'soft factors', due to their strong human component, are more difficult to translate into gradable parameters.
'Hard' factors are dealt with in the first sections of this assessment procedure: (A) the vulnerability of the target surface to cleaning, (B) the aggressiveness of the cleaning method, (C) the synergistic effects that may occur with specific method/substrate combinations, leading to a risk increment, and (D) the impact on the significance of the object. The first three factors are considered to influence the likelihood of damage occurring, whereas the consequences of such damage are assessed via the evaluation of the ensemble of values, i.e. the significance, of the object. Analytically, using a simple aggregation rule common in semi-quantitative risk analysis:

$$IR = [(A)\times(B)\times(C)]\times(D)$$

where:
$[(A)\times(B)\times(C)]$ = likelihood of damage
$(D)$ = consequences of damage

Computing the different factor assessments should therefore permit the planner to obtain an insight on the level of risk involved in the choice of each cleaning method.

The 'soft factors' are related to components such as 'conservation team skills' or 'control', and are dealt with in the 'Quality components' section. These 'soft factors' are sources of risk that also influence the likelihood of damage occurring, and their effect must be acknowledged, even if their assessment is somewhat less defined.

**Assessment Procedure – How to use**

After selecting the intended target surface for the concerned object, as well as which cleaning methods will effectively reach that target surface, it is then a question of choosing the method that will minimize the risks of damage.
As highlighted earlier, this risk assessment procedure starts with the analysis of four factors: the Vulnerability of the target surface; the Aggressiveness of the method; the Synergies between substrate and method; and the Impact on the significance of the object. When analysing these factors, bear in mind which risks the analysis refers to, as listed earlier: (i) mass loss; (ii) discolouration; (iii) indirect damage.
Please note that some factors used in this procedure are inherent to each object: the Vulnerability of the surface, as well as the Impact on Significance, depart from the evaluation of the object, and therefore, once assessed, are to be taken as fixed parameters. What may be changed is the chosen method, and by repeating the procedure with different methods it is possible to compare the different cleaning risks.
When preparing to apply the procedure, start by observing if there are differences within the object in terms of Vulnerability and/or of Significance:

- are there areas with localized increased cleaning difficulties?
- are there any particularly fragile areas?
- are there areas with different significance features (e.g. a plain wall and a decorated portal)?
- etc.

If the answer to any of these questions is yes, then define different representative areas – a risk assessment will be needed for each one. Then, select the cleaning methods that will prove effective for each area; resorting to experience, bibliography and/or expert consultation and cleaning tests in small secluded areas is advisable. Finally, follow the Cleaning Incompatibility Assessment Procedure along the following pages.

In the assessment of the four different ('hard') factors, evaluation scales are used that vary according to the need for distinguishing between the parameters that define each factor: Vulnerability and Impact on significance have their parameters rated between 1 (lower risk) and 5 (higher risk), whereas for the Aggressiveness parameters it was found that classifications between 1 (lower risk) and 10 (higher risk) would allow for a more accurate discrimination of the different methods; finally, the Synergies are considered as risk increments that should be classified between 1 (minimum increment) and 2 (maximum increment). In the end, the aggregation of the different factors is achieved via a simple multiplication, to give an idea of the risk level involved.

When going through this risk assessment process, please bear in mind that, within the proposed ranges (the blue bars), any number, integer or fraction/decimal can be chosen, according of course to the situation at hand. The ratings proposed for each factor are presented in the following sections.

**Factor A: Vulnerability to cleaning**

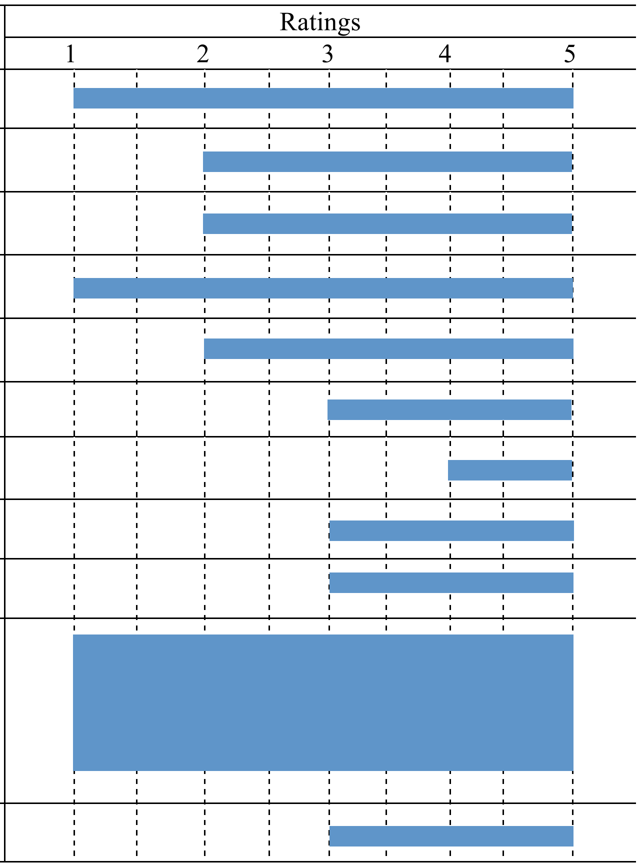
**Assessment Procedure**

When starting the process of assessing the incompatibility risk of a cleaning intervention, the vulnerability of the target surface should be analysed the first. Both the type and, where applicable, compactness (using open porosity as a parameter) of the substrate should be determined, and its surface condition should be assessed in terms of resistance to a cleaning intervention. Surface decay signs, and particularly actual or potential material losses, from small particles to large scales, including particle adhesion and cohesion, should be analysed in terms of severity of decay and susceptibility to solicitation.

The table below may then be used as an indication of the target surface vulnerability, where higher ratings should correspond to more vulnerable surfaces. After identifying the substrate type on the table (first column), a value should be chosen within the proposed ranges (the blue bars) that matches the substrate surface condition – higher values should correspond to increasingly more fragile conditions. For substrates not explicitly considered, it is suggested that the users try to find the ratings from the similitude of that substrate with any of those here identified. Please do not forget to consult the ‘Guidelines’ in the end of the table.

**Factor A: Vulnerability to cleaning** should be rated according to substrate type and target surface condition; for any given substrate, its susceptibility to damage increases with the seriousness of surface decay.

| Parameters – Substrate types | Ratings (1 2 3 4 5) |
|---|---|
| Granites and gneisses with porosity <2% | |
| Granites and gneisses with porosity > 2% | |
| Marbles | |
| Dense limestones and sandstones (Porosity <5%) | |
| Medium sandstones (5%< Porosity <15%) | |
| Medium limestones (5%< Porosity <15%) | |
| Very porous limestones and sandstones (Porosity >15%) | |
| Slates and other low grade metamorphic rocks | |
| Volcanic tuffs | |
| Brick masonry<br>Ceramic materials<br>Concrete<br>Basalt<br>Porphyry<br>High grade metamorphic rocks | |
| Mortars and renders | |



Guidelines:

- The probability of damage increases with surface decay: for each substrate type, within its respective bar, lower values correspond to sound substrates and higher values should be chosen for surfaces showing progressively more serious signs of decay.
- When the substrate exhibits different surface conditions throughout its extension, different representative assessment areas should be defined, since different assessments must be performed.
- Other plutonic rocks, e.g. diorites and other granitoids, should be analysed similarly to “Granites and gneisses”.
- When assessing surfaces with multiple materials, such as mosaics, tile pieces or stone intarsia, refer the

| |
|---|
| assessment to the frailest element. |

**Delphi debate on Factor A, explanations and questions to panellists**

*In general, the panellists agreed with the* ***assessment scheme****, but there were several comments on the need for a clearer explanation on how to use the table, and therefore the introduction was expanded.*

| ***Do you agree with the changes to the introduction of this section?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*The condition of the surface, with reference to decay signs (formerly described on the N.B. section of the table), was removed, since (1) it did not predict every situation; (2) it seemed to create some confusion and we feared it would become too prescriptive.*

| ***Do you agree with this deletion from the table?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Still regarding the assessment scheme, one panellist mentioned that porosity seems excessively relevant when compared to surface condition, and that a combination of surface resistance and surface condition should be added as parameters by subdividing each substrate type into different surface conditions.*

***Answer****: It was considered that this change would essentially provide the same information as the current table, namely because the surface condition proposed by the panellist is supposed to be taken into account under the actual rating scale. Furthermore, to add more categories would make the method slightly more prescriptive, and possibly overly long and complex, and therefore this suggestion was not followed.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Another panellist suggested that a parameter related to the surface texture of the different substrates should be added.*

***Answer****: While we agree that surface texture may influence substrate vulnerability, we see it more as a refinement that would only have a marginal influence in the final assessment: polished sound substrates are slightly less vulnerable than unpolished sound substrates, but both may still be given a low classification; as for deteriorated stones, the surface texture is already supposed to be used to assess the substrate condition and therefore it loses individuality and is then assessed altogether with the other surface problems. The suggestion was therefore not followed.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Regarding the* ***adding of substrates****, many suggestions were made, although only one panellist suggested a rating scheme for the proposed addition. Most suggested substrates were added to the table. Adobe and alabasters were suggested, but considered to be too specific and thus slightly too distant from the context of this procedure. Following the concept behind it, we aimed for a table with common substrates that would be indicative, and not prescriptive; we hope that now the substrates are enough for a planner to find a reference he/she can use or adapt.*

| ***Do you agree with all of the added substrates?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

| ***Do you agree with the rating scales for the added substrates?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

| ***Do you agree with not adding adobe nor alabasters?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |

| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* |
|---|

*The granites (now joined with the gneisses) were divided, following a panellist request for more information regarding their porosity and ratings.*

| ***Do you agree with the division of granites into these two categories?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Regarding the* ***porosity ranges for the sedimentary rocks****, twelve out of the fifteen respondents agreed with the proposed limits, and only two panellists suggested changing the upper limit from 15% to 20%, so the upper limit was kept at 15%. We therefore consider this substrate subdivision validated by consensus.*
*One respondent suggested drawing attention to pore size and interconnectivity, which are of course important parameters, but were considered more of a refinement, and, moreover, measuring difficulties could impair the use of the procedure. Therefore, these properties were not accepted.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Another respondent drew attention to stones with porosity extremes (above 35%). It was considered that this class is already duly covered by the 'Porosity > 15%' stone class, where only ratings between 4 and 5 are possible, which are already the highest possible ratings. The suggestion was therefore not accepted.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Regarding the* ***rating ranges****, different panellists made the following suggestions:*
*- The ratings might be overly complex: 1-2-3 ratings would make it clearer.*
***Answer****: There is not a strong motive for a 1 to 5 rating, but we do consider that it allows for a clearer distinction between different substrate situations. Furthermore, this suggestion conflicts with other opinions that asked for more complex scaling ratings. This suggestion was not accepted.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- Change all substrates starting at 1 to 2, so that the user does not get the wrong impression that they are not susceptible at all; and medium sandstones starting at 3.*
***Answer****: We believe that going through the procedure will raise the awareness of the user to the different sources of risk, even for substrates that are less vulnerable, e.g. sound dense granites and limestones. Furthermore, following this procedure will never return a 'risk free' result (minimum is 'low risk'). As for the medium sandstones, we do find that, for equal porosity values and surface conditions, sandstones are relatively less vulnerable than limestones, and thus the rating difference. The suggestion was therefore not followed.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- Renders starting at 2.*
***Answer****: We do believe that renders (now 'Mortars and renders'), even in a sound condition, are generally too vulnerable to be rated below 3. The suggestion was therefore not accepted.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- Dense limestones starting at 2 (akin to medium sandstones); and marbles starting at 3 (akin to medium limestones), as a way of being more defensive of surface morphologies, even when*

*they are in a good conservation condition. Alternatively, insert a note on the table or consider it under the Significance factor.*
***Answer****: We agree that in the previous version marble vulnerability was underrated, and therefore it is now starting at 2, similarly to medium limestones; however, it was considered that 3 would be too high. As for dense limestones, it was considered that, in a sound condition, their vulnerability may indeed be close to 1. As for the influence of surface morphologies (plain or decorated surfaces), we think it is more adequately considered under the 'Impact on Significance' factor.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

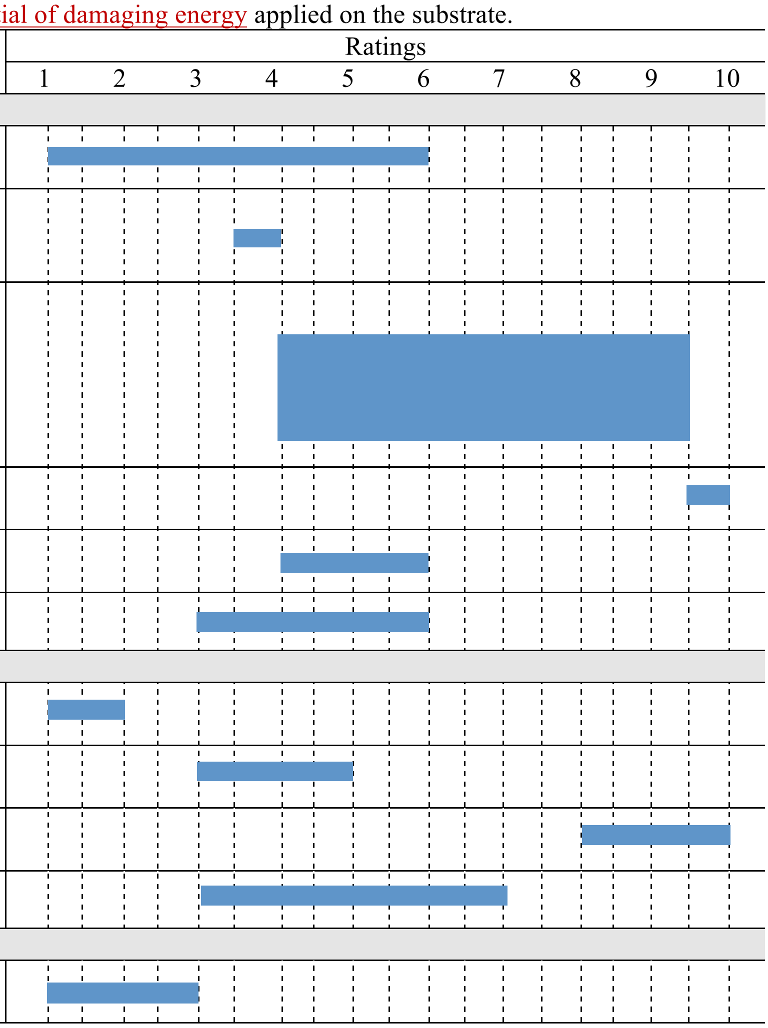
---

**Factor B: Aggressiveness**

**Assessment Procedure**
The cleaning method is then ranked in terms of its aggressiveness, i.e., potential to inflict damage regardless of the substrate where it is applied. This aggressiveness is highly dependent on the controllability that the method allows the operator; and on the potential of damaging energy that is forced upon the substrate. Please note that this is an assessment of the minimum risk that the method involves, and therefore it is presupposed that the method is handled by a knowledgeable operator; uncertainty about the operator skills must be considered in the end of this assessment (see 'Quality components'). Additionally, attention is called to the fact that, if using a combination of methods, (full) separate assessments are necessary.
The proposed aggressiveness assessment is described in the table below.

**Factor B. Aggressiveness:** each method should be rated according to the controllability it allows for a knowledgeable operator and/or the potential of damaging energy applied on the substrate.

| Parameters | Ratings 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mechanical methods | | | | | | | | | | |
| Hand tools (vacuum cleaner, chisels, brushes, scalpels and similar) | | | | | | | | | | |
| Particle jet :<br>- spherical microparticles (<0.1mm) set to low pressure (<0.05MPa) | | | | | | | | | | |
| - intermediate particle and pressure values – lower ratings for:<br>- low density particles;<br>- round shapes;<br>- smaller sizes;<br>- lower pressures. | | | | | | | | | | |
| - high pressures (> 0.5MPa) (particles of any size or shape) | | | | | | | | | | |
| Microhammer / pneumatic tools / rotary tools | | | | | | | | | | |
| Ultrasounds | | | | | | | | | | |
| Chemical methods | | | | | | | | | | |
| Neutral reagents (6<pH<8), incl. organic solvents | | | | | | | | | | |
| Weakly acidic (5<pH<6) or alkaline (8<pH<9) reagents | | | | | | | | | | |
| Strongly acidic (pH<5) or alkaline (pH>9) reagents | | | | | | | | | | |
| Chelating agents | | | | | | | | | | |
| Water-based methods | | | | | | | | | | |
| Without pressure (mist, poultices, sprinkling), with or without soft | | | | | | | | | | |



| Parameters | Ratings | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| brushing | | | | | | | | | | |
| Water jet: - low pressures (~0.2MPa-0.3MPa) | | | ■ | ■ | ■ | | | | | |
| - intermediate values | | | | | ■ | ■ | ■ | | | |
| - high pressures (>0.5MPa) | | | | | | | | | ■ | ■ |
| Steam jet | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Wet grit blasting | | | | | | | | | | ■ |
| **Laser** | | | | | | | | | | |
| Below ablation threshold | ■ | | | | | | | | | |
| Above ablation threshold | | | | | ■ | ■ | ■ | ■ | ■ | ■ |

Guidelines:
- Methods must be considered alone; if planning to use a combination of methods, separate assessments are required.
- The likelihood of damage decreases with the controllability of the method and increases with its potential of damaging energy. Higher values should be chosen for methods that are increasingly more difficult to control and/or that are applying more intense energies (e.g. larger or denser or more irregular particles, higher pressures, smaller nozzle diameters; higher or lower pH values; higher concentrations, etc).
- When assessing cleaning agents, and particularly chemical cleaners, remember that residues left on the substrate, causing staining or salt formation, are also damaging, and the rating should reflect this; be specially attentive when planning to use aromatic solvents; alkaline cleaners; poultice materials.
- Poultice media (e.g. clay, paper fibres or latex dispersion) are not specified here; the user should refer to the cleaning solutions used (water or chemical cleaning). When the risks associated to poultice cleaning are mostly related to the left residues, the use of a Japanese paper interface will lower them.
- Dry ice blasting should be considered as a particle jet (where the particles are solid $CO_2$).
- Bacterial and enzymatic cleaners should be considered as chemical cleaners.

**Delphi debate on Factor B, explanations and questions to panellists**

*Nine panellists generally agree with the **assessment scheme**, although suggesting some changes, such as adding some methods or changing some of the ratings; the introduced changes are listed below:*

*- the following methods were added to the table: steam jet; chelating agents; ultrasounds; rotary tools; and examples of hand tools. Dry ice, bacterial and enzymatic cleaners were inserted as notes in the 'Guidelines' section of the table.*

| ***Do you agree with the added methods?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

| ***Do you agree with their respective ratings?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- a 'Biological methods' class was suggested.*
***Answer:*** *The proposed class would just contain bacterial cleaners (since enzymes are chemical agents, i.e. their action is chemical, even if their origin is biological); this seemed to make the table overly complex and we believe that they can be justly considered as chemical cleaners, hence the note in the 'Guidelines'.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- the rating range for 'hand tools' was stretched to 6, as some hand tools can be more harmful, e.g. steel or brass brushes or chipping hammers.*
*- the rating range for laser above ablation threshold was widened to range between 5 and 10, as the damage caused by a laser above ablation threshold may only blast away a few particles or completely discolour the stone. In spite of two suggestions towards increasing the ratings for laser below ablation threshold, it was considered that, in this case, laser cleaning is self-limiting and therefore presents little risk to the substrate.*

| ***Do you agree with these ratings (for hand tools and laser)?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please suggest an alternative)* | | | | |

*- the particle jet class was simplified and made to include particle features such as shape or density;*
*- pH ranges were added for chemical cleaning solutions.*

| ***Do you agree with these changes?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist suggested that the ratings for chemical cleaning should be more conservative, since interventions with no scientific consultancy cause damages that are often only perceived in the long run.*
***Answer**: We agree that scientific consultancy is key in the success of an intervention and that, in its absence, damage occurs only too often. However, it was considered that any doubts about the judgement of the team involved, or on the 'recycling' of cleaning options from one object to the other, must be addressed in the end (under 'Quality components'), and the planner should multiply the final risk according to his/her understanding of the specific situation and context.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist finds that a rating range from 1 to 10 is excessively broad and suggests a range from 1 to 5 instead.*
***Answer**: The initial range considered was indeed between 1 and 5, but it was eventually found too narrow to allow for a clear differentiation between the methods.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist suggested that, besides pH, 'permanence time' should be added to the chemical methods.*
***Answer**: Permanence time is a relevant factor for every method and should be viewed as a question of damaging potential or controllability; any excessive contact between method and substrate will be a consequence of a high potential of damaging energy or of a poor controllability, and is therefore contemplated in the assessment.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Some of the panellists presented **objections to this assessment scheme**; their observations are listed below, along with some comments:*

*(i) one panellist suggests that the term 'controllability' should be restricted to chemical cleaning methods, and 'energy impact' be preferred for others.*
***Answer**: It was considered that, even if they are not mutually exclusive, both terms may be useful for a planner assessing the damaging potential of a given method.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please state the item and comment why)* | | | | |

*(ii) one panellist disagrees with the term 'energy density' being used for chemical methods; he/she further believes that "the aggressiveness of the chemical methods is not intrinsic to the method, but strictly dependent on the chemical nature of the substrate".*
***Answer****: The term 'energy density' was replaced with 'potential of damaging energy', which is believed to describe more clearly what the Aggressiveness table aims at measuring. It was furthermore considered that the cited observation does not invalidate the information in the Aggressiveness table.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please state the item and comment why)* | | | | |

*(iii) one panellist disagrees with this assessment scheme entirely because of not believing in analysing method aggressiveness independently from the substrate.*
***Answer****: We believe that an Aggressiveness assessment may be achieved and complemented by the method/substrate interactions described by the Synergies assessment. Therefore, Aggressiveness and Synergies are parts of the same assessment procedure and are supposed to be used jointly, when applicable.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please state the item and comment why)* | | | | |

*(iv) one panellist wonders how 'controllability' is measured and asks if it is a question of operator skills.*
***Answer****: The controllability of each method is not objectively measurable, and so it must depart from the perception of the planner. It is not a question of operator skills, which are presupposed, but of considering, for instance, that a cleaning poultice is more controllable than a particle jet; or that a water mist is more controllable than a water jet. Higher pressures, higher potentials of damaging energy and higher chemical reactivity tend to be less controllable conditions.*

*(v) one panellist questions the use of the term 'energy density' to make comparisons between mechanical and chemical cleaning methods; this panellist suggested that 'Potential for Adverse Impact on Substrate' might be a better term of comparing the aggressiveness of different methods.*
***Answer****: We agree that 'energy density' is indeed best referred to as 'Potential for Adverse Impact on Substrate'; we however opted for a simpler 'Potential of damaging energy'.*

| ***Do you agree with this change of term?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*(vi) the previous panellist also objects to the excessive complexity of this assessment, stating that aggressiveness highly depends on the operator skills, which cannot be objectively measured. A different panellist, albeit not objecting to the scheme, also pointed out that presupposing the operators' skills could pose an assessment problem.*
***Answer****: Inserting the competence and skill of the operators in this assessment scheme was initially contemplated but, as the panellists point out, very difficult to implement due to the difficulties of providing guidelines for its evaluation. We finally opted for presupposing this competence, in order to obtain a minimum risk, and to make that assessment as an independent step. In this way, competences and skills are to be evaluated at the end of the assessment procedure and risks can be multiplied whenever the planner has doubts on the operator skills and whatever the cleaning methods might be.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*The introductory section was expanded, hoping that the assessment scheme is now clearer.*

| ***Do you agree with the changes to the introduction of this section?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |

| *(Use 'x' to mark your answer; if you choose 'No', please state the item and comment why)* |
|---|

*One panellist commented, on section 7, that the procedure must contemplate the cases where "more than one single cleaning method is necessary".*
***Answer**: (We found it more adequate to answer this comment here because this is the section that was edited in order to follow this suggestion.) The cases of combined cleaning methods were not specifically described, and therefore the introduction to Factor B was edited to clarify this issue.*

| ***Do you agree with this edit?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

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**<u>Factor C: Synergies</u>**
**Assessment Procedure**
Once the absolute Vulnerability of the surface and the absolute Aggressiveness of the method are evaluated, it is necessary to analyse the synergistic effects that may arise from different substrate/method combinations. Indeed, some features of a given substrate may cause it to be more or less harmed depending on the method used. For instance, a salt laden wall may be seriously affected by a water-based method, whereas a purely mechanical method would cause no damage increment in that particular regard. These concerns were not contemplated in the previous sections: (1) the Vulnerability section rated the surface condition, and not the general decay mechanisms, and therefore the presence of clay minerals in the substrate composition or the occurrence of salts are not necessarily accounted for; also, (2) the presence of salts and/or clay minerals, while having a weakening effect on a stone, will not be as threatening for its integrity, especially in terms of side effects, if purely mechanical methods are used instead of water methods. Likewise, an acidic cleaning solution will not have as much damaging consequences on a silicate-based stone as it will on a carbonated stone or render, an issue which is not specifically addressed in the Aggressiveness section. The assessment should bear in mind that effects may manifest immediately or only in the long run.
It was considered that these substrate/method synergies have a risk amplification effect and therefore should be rated between 1 and 2; for example, a rating of 1.2 translates into a final risk increment of 20%. The table below lists the proposed risk ratings to evaluate these interactions.

**Factor C. Synergies:** synergies may occur whenever there is reactiveness between the substrate and the cleaning method or an increment of collateral risks.

| Parameters | Increments (1 – 2) |
|---|---|
| **Chemical methods** | |
| Causing chemical degradation/decomposition (e.g. acids or alkalis on carbonated substrates; chelating agents on substrates containing Mg or Ca) | 1.5 – 2 |
| **Any method requiring water** | |
| On highly absorbent/permeable construction materials | 1 – 2 |
| On substrates with soluble salts | 1.5 – 2 |
| On substrates with clay minerals | 1 – 2 |
| On substrates sensitive to temperature fluctuations when using steam (e.g. marbles) | 1 – 1.5 |
| On substrates subject to environmental freezing temperatures | 1 – 1.5 |
| **Laser** | |
| On coloured substrates or polymineralic stones | 1 – 1.5 |

Guidelines:
- The probability of damage increases with the <u>reactiveness</u> between substrate and cleaning agent.
- Mechanical methods were found not to have any particular synergistic effect with the substrate, and therefore, for these methods, synergy factor C=1.
- If the substrate/method combination is not contemplated in this table, then C=1.

- The circumstances listed are cumulative; if more than one specific circumstance coexist, then rate the respective parameters and multiply them (for instance C=1.2x1.5).

**Delphi debate on Factor C, explanations and questions to panellists**

*Nine of the panellists agreed with the assessment scheme used for the Synergy section. However, some panel members found the scheme (including assessment ranges), either unclear or presenting information which is, or could be, included in the previous tables. Therefore, the introduction to this section was expanded, hoping to address these issues.*

| ***Do you agree with the changes to the introduction of this section?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Some panellists suggested that the **table parameters** should be altered; the proposed edits are, as follows:*
*- one panellist would add mechanical methods, as they can be used as complements of chemical cleaning and highly depend on the sensibility and skills/training of the operators and on the phase they are used (pre- or post-chemical cleaning)*
***Answer**: Due to the difficulties in assessing operator skills, issues related to these are addressed in the 'Quality components' section, where the user is advised to increment the risk whenever there are doubts about the professionals involved. As for method combinations, the planner should make separate assessments, one for each method, but of course consider the effects of the first method on the surface vulnerability when assessing the second method.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- "marble when using steam" was replaced by "substrates sensitive to temperature fluctuations", following a panellist suggestion.*
*- the same panellist suggested that chemical cleaning should be subdivided into "chemical degradation/decomposition" and "formation of stains/salts".*
***Answer:** While we followed the first suggestion ('Causing chemical degradation/ decomposition' was formerly 'Reactive with the substrate'), the 'Formation of stains/salts' is not a synergy, since it does not depend on the substrate – it is an Aggressiveness issue, and therefore this part of the suggestion was not followed.*

*- the same panellist had some doubts on the "criteria" listed under 'Water-based methods' (now 'Any method using water') and 'laser'.*
***Answer:** We would like to point out that these are not "criteria", but parameters describing the specific circumstances that should be evaluated in order to assess the Synergies factor. This factor should only be rated above 1 if any of these circumstances occur.*

| ***Do you agree with these changes to Synergies table?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- one panellist "would add more [parameters]. For example, surfaces with black crusts, surfaces with old treatments like hidrophobization or consolidation, surfaces with graffiti, etc."*
***Answer**: Surface condition, and namely the presence of black crusts and/or old treatments, should be considered in the Vulnerability section; we could not identify a situation where these would implicate a synergetic effect.*

*- one panellist "would remove the environmental freezing temperatures, as it doesn't depend on the method itself and, moreover, it applies also to chemical methods which, generally, also use water".*
***Answer**: We agree that it is not about the method, but about the risk of the operation; however, this risk is increased if the temperatures drop below zero during the cleaning period, and the effect is particularly serious for methods using an abundance of water, such as water jets or*

*mists. Therefore, we kept the 'Environmental freezing temperatures' but replaced "Water-based methods" with "Any method using water".*

| ***Do you agree with the explanations offered and edit to the table?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Concerning the* ***increments****, only five respondents explicitly agreed with the proposed ranges, while other respondents chose not to comment because of not having a clear opinion on this topic or because of having previously raised objections to the assessment scheme. Two panellists found the increment range unclear, and further information was added to the introductory section and to the table trying to better clarify classifications under this factor.*

| ***Do you agree with the proposed ratings for this factor?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist, and then three more panellists when answering section 5 ('General appreciation of the chosen factors'), believes that the increment assessment should range between 1 (one) and 3 (three), since "1 might be considered as 'good' and 2 as 'bad'".*
***Answer****: This change was not implemented because parameters included under synergies were meant to function as "risk amplifiers", and thus the chosen range; 3 would amplify the risk threefold, which was considered excessive.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist remarked, "synergistic impacts could be usefully considered as either short-term or long-term".*
***Answer****: for the purposes of this assessment, they are identical in importance, and both types of impacts should be considered; a sentence to that effect was added to the introduction to the Synergies section.*

| ***Do you agree with the adding of this sentence?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

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**Factor D: Impact on Significance**

**Assessment Procedure**

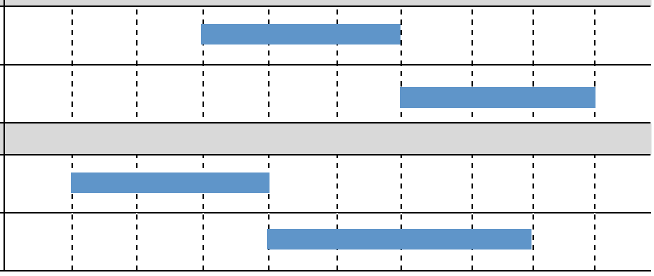
Finally, the seriousness of the consequences of damage occurring during cleaning should be assessed. This means asking the stakeholders involved: "How much would the damage of the surface material affect the significance of the object?", i.e., "How relevant is the surface in the overall significance of the object?" Notwithstanding the necessity of a lengthier analysis beforehand, it is proposed that this assessment may be based on the table below.

The table separates listed and unlisted objects, assigning more importance to the former. While acknowledging that many important objects may not be officially listed, it is considered that, among the vastness of objects with cultural significance, some have a higher significance than others, and their listing status was used as criterion for lack of a better option. One should never forget, however, that all objects that come under the current analysis hold cultural significance to some extent, since this method is specific for heritage cleaning. Furthermore, the criteria described below are indicative, and the planner's judgement is advised for cases where values are very high and/or held strongly by a given community, even though the object is not officially listed.

Within each category of objects (listed/unlisted), it is still important to assess how relevant are the surfaces for the overall significance. This may be judged by considering the effects of the loss of surface material: generally – though not always – losses will have a greater impact on significance if the surface is decorated, or has a particular texture, than if it is a plain building block with no particular surface features. Again, the planner's judgement and stakeholder consultation are advised in order to make sure that no relevant surface features go unnoticed.

**Factor D: Impact on significance**: assessing the consequences of damage means considering how valuable the surfaces are.

| Parameters | Ratings | | | | |
|---|---|---|---|---|---|
| Surface relevance | 1 | 2 | 3 | 4 | 5 |
| Listed or equivalent objects | | | | | |
| Surfaces of lower relevance | | | | | |
| Surfaces of higher relevance | | | | | |
| Unlisted objects | | | | | |
| Surfaces of lower relevance | | | | | |
| Surfaces of higher relevance | | | | | |



Guidelines:
- the seriousness of damage consequences increases with the relevancy of the target-surface materials for the overall significance of the object.
- formal aspects such as the presence of sculpted work, carvings or other decoration patterns are generally associated with higher relevance; plain ashlars or rubble masonry may be comparatively (though not necessarily) less relevant for the significance of the object.
- areas of different relevance may coexist in the same object (e.g. pavements and portals); if this is the case, representative areas must be chosen and assessed separately.

**Delphi debate on Factor D, explanations and questions to panellists**

*Eight panellists agreed with the* ***assessment scheme*** *for the 'Impact on significance', with one panellist suggesting a minor change: replacing the terms "high/low relevance" with "ornamented/plain surfaces", so as to eliminate the effect of possible carelessness for low relevance surfaces.*
***Answer****: This change was found to cause an over-specification that would narrow the application of the scheme, and thus not implemented. A note was nevertheless added to the table guidelines drawing attention to the ornamented/plain dichotomy; furthermore, "high/low relevance" is now "higher/lower relevance", in order to accentuate the relativity of the adjectives.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Two other panellists agree with the scheme conditionally:*
*- for one, the scheme only works for objects where surface is the key attribute. This panellist further believes that the impact on significance is a subjective factor that may require previous studies "based on quantitative cost-benefit analyses".*
***Answer****: Regarding the concern of surface being the key attribute of the object, it is argued that a cleaning procedure is always a surface-level intervention and therefore impacts to the object must be assessed at surface level (and potential side effects were assessed under Synergies).*
*We furthermore concur with the need for previous significance studies prior to any conservation intervention, which may or may not be complemented by cost-benefit analyses. However, in practice, those studies are not always performed, and to require them here would plausibly deter the planner from using the procedure.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- for the second panellist, the scheme will be valid only if the significance assessment consults all the stakeholders, since different opinions may occur.*
***Answer****: Stakeholder consultation is considered crucial in the context of this assessment, and therefore the introduction to this section was edited in order to highlight this issue.*

*Two panellists expressed doubts regarding the criteria used to describe and/or rate the consequences of damage, and therefore the introduction was expanded to try and make these clearer.*

| ***Do you agree with the changes to the introduction of this section?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Two panellists disagree with the scheme entirely: for one, significance is too subjective a topic, and therefore difficult to assess; for the other, including a significance assessment may open a "Pandora's box – for example who decides what's relevant and what's not?", something which is "a completely separate argument" when analysing "the impact of cleaning on a stone surface".*
***Answer****: While the subjectivity of significance assessments is acknowledged, significance today is the cornerstone of heritage conservation, and we were unable to find a suitable pragmatic alternative to evaluate and rank the seriousness of damage consequences that may arise from cleaning interventions. Using the "listed/unlisted" criterion intended precisely at making the assessment less subjective and the process less chaotic. Subjectivity when assessing significance is an inescapable reality, and since significance cannot be ignored; we merely tried to frame its assessment and draw attention to its consideration. Furthermore, the simple fact that the panellist considers it as relevant as to name it as a "Pandora's box" can be interpreted as existing an absolute need to try to clarify it, in spite of the difficulties inherent to this objective.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Regarding specifically the* ***"listed/unlisted" grouping****, only four panellists agree with this grouping scheme unreservedly; four other panellists do not think that the listing of an object is necessarily a match to its significance, and expressed concerns about the implications for significant yet unlisted objects; however, these panellists acknowledged the difficulties in coming up with a different assessment grouping and/or recognized the pragmatism of such a division, and therefore agreed with the scheme proposed.*

*Three panellists, however, disagree with assessing the significance of an object based on its listing status and two of them proposed the following changes: (1) the plain removal of the listed/unlisted division, with the ratings varying between 1 to 3 for low relevance surfaces and 3 to 5 for high relevance surfaces; or (2) the removal of the listed/unlisted division plus making the ratings depend on significance assessments made prior to the intervention.*
***Answer****: While acknowledging the possible flaws of this grouping, it is considered that some objects are more culturally significant than others, and this should be expressed in this ranking, since consequences of losses on these objects will be more serious than on comparatively less significant ones. The listed/unlisted status of the object does not depend on the planner, something which was considered desirable to make the assessment slightly less subjective. Nevertheless, the words "or equivalent" were added to the table, for the cases where the objects are not yet listed but are very significant.*
*Making the ratings depend on a thorough significance assessment would of course be the best scenario, but unfortunately significance assessments are still not a standard procedure, at least in Portugal, and to require such an assessment could hamper the use of the procedure altogether, since evaluating consequences is a crucial part of risk assessment.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist would add the factor 'Formal/decorative/sculpted work', evaluated via the parameter 'presence or absence of decoration', which would be rated from 1 to 2, similarly to the Synergies factor, as a way of complementing the 'Impact on Significance' factor in assessing the consequences of cleaning. Alternatively, a note should be made in the 'Impact on Significance' table instructions; either way, the surface morphology should be unequivocally accounted for. Another panellist, albeit disagreeing with the assessment scheme, also mentions*

*that it might be useful to differentiate between: carved work; architectural detail; ashlar; rubble masonry.*
***Answer****: We agree that the presence of decoration is a key issue, but believe that it should be accounted for under the surface relevance parameters, and therefore added a note in the 'Guidelines' section of the table.*

| ***Do you agree with these changes to the table?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist additionally commented on the need for legislation to dim the contrast between listed and unlisted objects, since it is not an adequate mirror for significance. Oftentimes, the conservation and restoration of unlisted but sometimes very relevant objects is not accompanied by the same scientific, technical and operational requirements that are applied to the listed ones. It is therefore critical, in the opinion of this panellist, to include the risk factor on the tender documents.*
***Answer****: We agree with this comment entirely, and hope that this procedure constitutes a step in that direction.*

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**General appreciation of the chosen factors**

*[This section is not a part of the assessment procedure; it was, however, a part of the Delphi panel questionnaire and its conclusions are therefore included here. Please note that some of the comments made by the panellists here were already included and answered in their respective section.]*

**Delphi debate on the appreciation of factors, explanations and questions to panellists**

*Regarding the* ***appreciation of the different factors*** *(Vulnerability, Aggressiveness, Synergies and Impact on Significance):*
*- twelve panellists agree with all the factors; one of the panellists further added a positive note on how all the varied factors fit the different dimensions involved in conservation; another panellist had some issues with the terminology, and we hope that the edits now introduced corrected or clarified this problem.*
*- one panellist had doubts about the double counting in the Synergy factor. This question was addressed in the Synergies section.*
*- two panellists agree with all the factors except D (Impact on Significance). Their questions were addressed in the respective section.*
*Please note that, given these numbers, we considered the four factors generally approved by consensus; this second round focuses on the discussion of details for each factor.*

*Regarding the* ***removal of any of the factors****:*
*- eleven panellists would not remove any factor;*
*- the panellist that has doubts about the double counting on Vulnerability and Synergies, would remove the latter. This issue was addressed in the Synergy section.*
*- one panellist, whilst retaining all the factors, would "make a much clearer distinction between the first three, and Impact on Significance, possibly not considering them on the same scale as each other."*
***Answer****: the difference between factors A, B and C and factor D was highlighted in the general introduction by making the risk formula explicit in the beginning of the procedure.*

| ***Do you agree with introducing the risk definition in the beginning of the procedure?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- one panellist suggests that "Synergy could be included within aggressiveness; significance is an emotive term and could be re-phrased 'Impact on Stone Surface' to more clinically describe and differentiate between the different cleaning methods".*
***Answer****: We were unable to include the Synergies within the Aggressiveness in a systematic way; in fact, that was the departing point, but we ended up having to separate the two factors in order to more systematically introduce staining and collateral damage. As for the renaming of factor D, we do believe that 'Impact on significance' is more apt, plus it also helps in*

*raising the planner's awareness for this crucial, and oftentimes disregarded, dimension of the object.*

*- one panellist would remove factor D (Impact on significance). This issue was addressed in its respective section.*

*Regarding the* ***adding of a different factor****:*
*- eight panellists would not add a new factor; of these, two panellists highlighted that:*
*- "it seems that the inherent characteristics of the substrate and of the cleaning method are considered adequately"*
*- "I would not know how to "codify" significance and cultural/social aspects into objective parameters".*

*- one panellist would add a factor about the deposits to remove and a different panellist would add (1) "degree of cleaning, according to the degree of dirt deposit" and (2) "ratio of degree of cleaning to the aggressiveness".*
***Answer****: We were unable to parametrize or construct a table for the assessment of these suggestions. In our understanding, deposits are an essential parameter when analysing the effectiveness of the method, which is presupposed here. Although accepting that the degree of cleaning is not totally independent from the method used to reach it, we have to presuppose that the target surface (degree of cleaning) is established beforehand and it is non negotiable to accommodate a higher or lower aggressiveness method. (We are not entirely sure of having interpreted the panellist suggestion correctly).*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- one panellist finds that "The risk for the operator and for the environment should also be considered. A rating scale could be: 3 (dangerous), 2 (requiring very strict conditions for the protection of the operator or the environment), 1 (safe for the operator or the environment)."*
***Answer****: these risks are real possibilities, but will happen only when the safeguarding measures inherent to the concerned method are not taken in due consideration. To a certain extent, this aspect may be taken in a way similar to the one proposed to deal with effectiveness. For the intents and purposes of the present assessment, it is assumed that protection of the operators and potential environment impacts are eliminated or minimised.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- one panellist would add a "formal/decoration/sculpted work" factor. This suggestion was addressed in the 'Impact on significance' section.*

*- one panellist suggested adding:*
*(i) the parameter of selectivity to the Aggressiveness section, to rate the ability of the method to preserve layers that are very fine or fragile.*
***Answer****: This, we believe, is accounted for via the Controllability parameter, which should be considered in the rating of the different methods.*

*(ii) the permanence of residue, specifically for chemical methods; namely, to prevent the cases where non-volatile agents are used on very porous stones, and where complete removal or neutralization might not be achieved.*
***Answer****: The 'Guidelines' of the Aggressiveness table were edited to draw attention to the cases where residue of the cleaning agent might be left on the object.*

*(iii) a parameter related to the need to allow gradual cleaning, in the Aggressiveness section, covering all methods, since "sometimes the method is quite independent of the operator and does not allow you to control the level of cleaning."*
***Answer****: The Aggressiveness table is built on the hypothesis that the operators are skilled and knowledgeable. We consider gradual cleaning to be related to selectivity and, again, to controllability, which is already a parameter for the method ratings in that section.*

| ***Do you agree with the explanations offered?*** |
|---|

| ***Yes*** | | ***No*** | | ***Comment:*** |
|---|---|---|---|---|
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*- one panellist would add a factor related to the validation of the methodologies prescribed in the contracts, as a form of incorporating risk into the planning, particularly in the cases where cleaning solutions are copied from one object to the other, without critical judgment. Assessing material behaviour after interventions would be equally important, according to this panellist, as well as the implementing of controlling teams to verify the conservation works.*
***Answer****: We agree that too many interventions are planned and carried out lacking an in-depth consideration of their specificities, and this is why we introduced some elements into the 'Quality components' section, including the need for performing deposit impact assessments and defining the cleaning level, for instance by means of a reference surface; the same stands for the controlling of the interventions – adequate resources, both human and material, must be planned for and made available.*
*We have also interpreted this suggestion as the addressing of the difficulties that owners/authorities may experience in identifying flaws in intervention proposals from prospective contractors, and thus the suggestion of asking for a validation step. Subjects such as this are relevant aspects that are supposed to be adequately addressed under 'Quality components', and not necessarily requiring a new factor.*
*Finally, we of course agree on the importance of assessing material behaviour after interventions, namely because some harmful effects may become noticeable only some time after the cleaning actions. To analyse this aspect is of great importance when making a post-cleaning assessment of risks, but it is not a timely action to be included when planning a cleaning intervention. In this context, it becomes a "knowledge tool" instead of a "planning tool".*

*- one panellist reiterated here the need to "differentiate the factors more" as per previous suggestions.*
***Answer****: the suggestions were considered and explanations given in the respective sections.*

*Regarding the* ***rating scales of the different factors:***
*Eight panellists agreed with the proposed scales. One panellist, however, found the rating system to be overly complex, and we hope that the edits made to this new version make them clearer.*

*Specifically regarding the rating for the Synergies factor, several issues were raised by different panellists, including:*
- *two panellists found the section unclear;*
- *four panellists found the scale too narrow, or the ratings too benevolent, and proposed to raise the upper limit.*

***Answer****: We hope that the edits to this section made it clearer. As for the widening of the Synergies assessment scale, the proposed change was not implemented because a threefold increase of the global risk due to Synergies was considered excessive, as explained above.*

*One panellist found that "items related to cleaning of biological colonisation, graffiti, stains" were missing, and has the opinion that "…the actual concepts seem to be limited to the cleaning of gypsum layers".*
***Answer:*** *On this topic, we would like to highlight that deposits are not considered in this procedure, as effectiveness is presupposed, as explained earlier. The different methods listed include chemical cleaning agents, which are the ones more commonly used for the removal of the cited deposits, and so, in our opinion, they are as much or as little considered as any other type of deposits. The procedure is absolutely not designed with black crusts as the unique "soiling paradigm".*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

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**Getting a risk estimate – Cleaning risk matrix**
**Assessment Procedure**

As highlighted in the introductory section, risk equals the product of the likelihood and the consequences of damage occurring. In this analysis, factors A, B and C are related to the likelihood of damage occurring, whereas factor D assesses its consequences.
The assessment of factors A through D should allow the planner to verify where a given object/cleaning method combination stands – qualitatively, or semi-quantitatively – in terms of risk. It is proposed that the likelihood factors (A, B and C) are aggregated via a simple multiplication and that the obtained value is then cross-checked with the consequence factor (D) in the cleaning risk matrix below. For example, in a situation where a non-significant high density stone surface in a sound condition is cleaned with water under high pressure, then: A=1; B=10; C=1; which means that L=10. For D=1, the cleaning risk is 'Very low'; for a significant surface (D=5), however, the risk would be "High/Very high", as the potential loss of value is greater.
Please note that the product of all the semi-quantitative assessments is not to be used directly, since a simple product would not allow for a clear distinction between risks that are very likely but have no serious consequences and risks that are unlikely but can be extremely damaging. For this procedure to function as a planning tool, those different contexts must be identified, so that choices become clearer.

**Cleaning Risk Matrix Proposal**

| **Risk** | | **Consequences (D)** | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | **Negligible** | **Moderate** | **High** | **Very high** | **Severe** |
| **Likelihood (L=AxBxC)** | **Very high** L>40 | Low | Medium | High | Very high | **Extreme** |
| | **High** 20<L<40 | Low | Medium | High | High | Very high |
| | **Moderate** 10<L<20 | Very low | Low | Medium | High | Very high |
| | **Low** 5<L<10 | Very low | Low | Low | Medium | High |
| | **Very low** L<5 | Very low | Very low | Low | Low | Medium |

In simple terms, this can be considered as a 'hard' matrix, meaning that, for a given substrate, the cleaning risk cannot be lowered unless you change the cleaning method. Therefore, risks more serious than 'medium' should immediately alert for the need of a more careful consideration of the cleaning method; reassessments with alternative methods should be tried to see if the risk involved may be lowered.
When no feasible alternative is foreseen for the method under analysis, consider possible minimizing actions, such as reducing the concentration of an acidic solution, reducing the dwelling time of a chelating product, interposing a Japanese paper when using poultices, etc.

**Delphi debate on the Cleaning Risk Matrix, explanations and questions to panellists**

*Nine panellists agreed with the zoning. Three panellists agree with the model, but believe some testing is needed to verify and/or adjust the assessment areas.*
*Panellists are invited to test the procedure resorting to cases that are familiar to them and see if the results are valid. Also, some examples of application were added to the end of this document to illustrate the procedure in its current version. These examples are not supposed to be integrated in the final text of the procedure.*

*Some panellists found the matrix unclear, and therefore the text was edited to make its use more straightforward by means of an example.*

| ***Do you agree with the changes to the introduction of this section?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist commented that the attributing a classification of "Medium" to the L<5 class seemed "excessively prudent", and questioned whether cleaning a high- or very high-significance surface should always be considered as a 'Medium' risk action. The panellist further commented that in general the risk grades seemed to be overly conservative, although the panellist agrees with this overrating of the risk.*
***Answer****: for the highest significance surfaces (D = 5), we found that the seriousness of damage consequences required a "Medium" risk classification at least, whatever the method under analysis. Nevertheless, after reanalysing our case studies, we realised that a certain excess of prudence might have been used in the first matrix, and so a few changes were made.*

| ***Do you agree with the proposed changes to the matrix?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist commented on the need to consider effectiveness when comparing the risks of different cleaning methods.*
***Answer****: Indeed, it is useless to compare two methods in terms of risk if one of them is not effective in removing the intended deposits; but it is also useless to assess the risk of an ineffective method, which is why method effectiveness is presupposed, as explained earlier and added to the procedure introductory section.*

| ***Do you agree with the explanations offered?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

---

**Quality components**

**Assessment Procedure**

The table below shows planning Quality components that may help configure an optimal intervention scenario or, quite the opposite, cause the whole intervention to irrevocably fail. Unlike the previously discussed factors, which were rated according to given features of the object or cleaning method, classifying the Quality components depends on if and how they are planned.
The consideration of these components under this chapter and not as 'hard' factors derives from the evident difficulty on finding the appropriate parameters to rate them properly. These are strongly human-dependent parameters that are best considered as 'soft' parameters, for whose analysis a careful scrutiny is necessary. A careful and considered planning may limit the risk values to those reached with the 'hard' factors, whereas an ill considered or absent planning will multiply the cleaning risks involved by the multiplying factors proposed in the table below.
In this perspective, these 'Quality components' are to be considered as risk factors that will increase the likelihood of damage occurring. The previous Cleaning Risks Matrix classifications may still be used as a reference once the Likelihood (AxBxC) is multiplied by the Quality component values obtained, and then cross-checked with the consequences (D).

| **Quality components:** these are risk-multiplying factors whenever they are neglected. |
|---|
| Preparatory – may increase final risk by a factor of **1 to 3** |
| Significance analysis |
| Deposit impact assessment (consider historical/aesthetical/chemical/physical/social/other impacts) |
| Documentation of the conservation condition (to have such a documentation will lead to an easier and more correct assessment of Vulnerability) |
| Defining, characterizing and justifying the cleaning level (*) |
| |
| Required team skills – may increase final risk by a factor of **1 to 5** |
| Adequacy of operators training and experience |
| Experienced conservator-restorers integrated in the organizing and execution teams |
| Adequacy of the team structure |
| |
| Planification – may increase final risk by a factor of **1 to 3** |

| | |
|---|---|
| | Adequacy of time and budget constraints |
| | Adequacy of the tools, instruments and products available |
| | Adequacy of equipment and logistics |

| | |
|---|---|
| Control – may increase final risk by a factor of **1 to 2** | |
| | Adequacy of the controlling methods (e.g. timely definition of reference surfaces) |
| | Adequacy of the controlling agents |

Guidelines:
- to know exactly what must and must not be removed is crucial; it entails not only a significance analysis, but also how the deposits impact on that significance, in the short and in the long run; future uses must be considered.
(*) for more complex interventions, cleaning tests may be advisable at this stage.
- requiring adequately trained and experienced professionals, including conservators-restorers in key organization and execution positions, and ensuring adequate means and team structures are all sine qua non conditions for accomplished cleaning interventions.
- a well defined and characterized reference surface that will aptly function as a control tool, and was previously agreed with the contractor; as well as adequately trained control professionals, are essential for a satisfactory result.

**Delphi debate on Quality components, explanations and questions to panellists**

*Thirteen panellists generally agree on the relevance of the suggested components.*

*One panellist asked if the parameters could be assigned weights or somehow organized in a matrix that would be correlated with the Cleaning risk matrix, since planning issues may considerably increase the results of the latter. Another panellist asked about the possibilities of proposing ratings for the 'Quality components', since they represent "very relevant" risk factors as well. For yet another panellist, team experience is particularly relevant.*
***Answer**: The 'Quality components' table includes aspects whose contingency makes them extremely difficult to assess, and therefore we opted for assigning weights in the form of multiplying factors that raise the risk obtained following the Procedure. We agree that the team skills are key to the success of an intervention, and multiplying factors were assigned to each group of parameters to reflect this importance. The interaction between the "Quality components" and the "Cleaning risks matrix" was better explained in the introduction to this section.*

| ***Do you agree with assigning risk-multiplying factors to the parameter groups?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

| ***Do you agree with the multiplying factors chosen?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment and propose new values)* | | | | |

*One panellist commented that "All the planning factors listed here are very important to consider in any case when a cleaning process will be planned but most [...] are common to all type of conservation/restoration plan (see for example: required team skills, or controls)." Another panellist corroborated this opinion, further highlighting the problems that may arise when site authorities are not aware of the prominence of these parameters for successful interventions.*
***Answer**: We entirely agree that the importance of these 'Quality components' crosses all steps of a conservation intervention, and hope to raise awareness for these issues next to anyone using this procedure.*

*One panellist commented that the parameters are relevant, but unrealistic and more of a wishful thinking.*
***Answer**: As mentioned on the previous answer, this procedure intends to raise awareness for the risks involved in cleaning interventions on heritage objects, and to take a step from 'wishful thinking' towards 'reality'.*

*One panellist disagreed with the table, and breaks down the planning of heritage cleaning differently (bullets below are edited citations from this panellist):*
- *significance is presupposed;*

- *phase 1: Understanding the building/surface: vulnerability analysis, including deposit impact assessment; should conclude on whether cleaning is appropriate or not (e.g. questions to ask - is the goal to remove all soiling, or just soiling that is causing stone alteration? etc.), and broadly what type(s) of cleaning could be considered;*
- *phase 2: Determining a cleaning method and appropriate level of 'clean': Defining, characterizing and justifying the cleaning level (which is subjective);*
- *time/budget should be entirely separate from objectively understanding the vulnerability and the cleaning needs of a stone surface.*

***Answer**: The planning sequence suggested by the panellist is perfectly fine for an experienced professional that masters the entire conservation process – not the target group of this Procedure. On the other hand, and even though this procedure is designed for the cleaning of heritage – and therefore significance-bearing – objects, we consider that presupposing significance is not enough and that analysing and tentatively assessing how surface features embody that significance is crucial in the "understanding of the building/surface" and in the 'Defining, characterizing and justifying the cleaning level' (e.g., sometimes deposits play a part in the significance of the object). We do agree that: (1) to name this section 'Planning' may be error-inducing, and therefore the section was renamed 'Quality components' and (2) a better distinction between 'Preparatory stages' and 'Planification needs' was necessary, and therefore the table was edited to highlight this issue.*

| ***Do you agree with naming this section 'Quality components'?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

| ***Do you agree with the adding of the 'Planification needs' component group?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Two panellists, albeit considering that the listed components cover most relevant aspects, made the following comments:*

*- "in risk assessment, a certain degree of subjectivity inherent to decision making must be considered";*

***Answer**: We also believe that conservation decision-making bears a certain degree of subjectivity, which we try to dim with this procedure. We are of course aware that subjectivity cannot be altogether eliminated, since Conservation is a discipline that holds a very strong human component.*

*- these components are applicable in "an ideal scenario where conservator-restorers are recognised as the leaders of a conservation project and/or cleaning intervention", but not necessarily when "the person in charge, although qualified [e.g. an architect], has little up-to-date knowledge from contemporary studies by qualified conservators in the field."*

***Answer**: This procedure aims at supporting whoever is in charge of the intervention, and particularly those that lack up-to-date conservation knowledge, regardless of their education background. Of course a person who is unconversant in the matter will not be able to handle this procedure. However, and excepting for persons totally ignorant of the basic aspects related with stone heritage cleaning, we think that this procedure is accessible to non-experts and it is certainly not only for conservation scientists and conservator-restorers. An architect, even with "little up-to-date knowledge" on these matters, will surely be able to apply the methodology.*

*Regarding the **adding of other Quality components**, one panellist proposed: (1) definition of the cleaning method according to cleaning level and (2) cleaning tests on sample area. Another panellist also mentioned the need for including cleaning tests on the table, although as a separate component group, that would comprise the selection of the testing area and the analysis of the tests.*

***Answer**: The underlying concept of the methodology is that, once a target cleaning level is defined and the effective cleaning methods are pre-selected, the procedure would help finding the most adequate method. A reference to cleaning tests was added to the table 'Guidelines', as a footnote for 'Defining, characterizing and justifying the cleaning level'; we believe that this mention, along with that of 'reference surfaces' on the Control components are sufficient for drawing the planner's attention in the context of this procedure.*

| ***Do you agree with the insertion of the footnote on cleaning tests?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist suggested that "mapping of the conservation state" should be added under 'Preparatory'. This suggestion was followed.*

| ***Do you agree with this inclusion?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*Two panellists asked what kind of impact was meant by 'Deposit impact assessment'.* ***Answer****: All dimensions of the object, or at least the most relevant, must be assessed, and therefore the cited table item was edited to specify this requirement.*

| ***Do you agree with this edit on the 'Deposit impact assessment' item?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist suggested adding a component regarding the quality and adequacy of cleaning products and the commitment of the contractor to using those products.*
***Answer****: Product adequacy was added under the 'Planification' component group; as for the commitment to their use, we see it as a Control issue, and a well-prepared control team should be able to tackle this responsibility.*

| ***Do you agree with the adding of 'Product adequacy'?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panelist suggested adding the 'definition of the conservation aim(s)' and the 'considering of the future use(s) of the object', for the cases where the cleaning intervention is not part of a greater conservation project that would address those issues.*
***Answer****: The consideration of future uses was added to the table 'Guidelines'. As for the 'Definition of conservation aims', we consider that, in case where the conservation intervention is limited to cleaning, the 'Defining, characterizing and justifying the cleaning level' would be sufficient.*

| ***Do you agree with this addition to the table Guidelines?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist highlighted the importance of good planning for reducing risks and commented that choosing reference surfaces from test patches with different cleaning levels and justifying that choice are crucial before beginning the overall cleaning.*
***Answer****: We of course agree that planning plays a chief role in the success of a conservation intervention, and hence the 'Quality components' section. As for the justifying the cleaning level, the table was edited to include testing (see above) and we further added the need for utilizing reference surfaces under the 'Control' components group.*

| ***Do you agree with this edit to the 'Adequacy of control methods' subcomponent?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist suggested that the risk scale could be improved by analysing past heritage cleaning projects in terms of technical execution and, particularly, in terms of planification and management, which are frequently neglected. Furthermore, since oftentimes intervention reports are incomplete or non-existent, the need for making them compulsory should be highlighted.*
***Answer****: The risks matrix was in fact elaborated with some case studies as benchmarks. This information was not sent in the first round but was now added to the end of this document. For the 'Quality components' table, these case studies have been very informative and taken as a qualitative input, in the same way as we propose now for the future use of this table. Regarding*

*the intervention reports, they are of valuable 'knowledge tools' for making post-cleaning assessments; however, we considered them too specific to be included here as a 'planning tool'; they should be dealt with by the Control team.*

| ***Do you agree with our reasoning?*** | | | | |
|---|---|---|---|---|
| ***Yes*** | | ***No*** | | ***Comment:*** |
| *(Use 'x' to mark your answer; if you choose 'No', please comment why)* | | | | |

*One panellist wondered about how to link factors A, B, C and D with the 'Quality components' table. The panellist further mentioned that the Procedure needs "additional improvement and corrections" before implementation.*
***Answer**: It would be interesting, as a future exercise, to evaluate how these 'Quality components' affect the different factors, but would be too complex to implement on this stage of the work. We nevertheless hope that the improvements ensued from this Delphi panel will constitute a significant step towards its implementation.*

*One panellist suggested a different procedural logic: "start from the cleaning methods and discuss the advantages/disadvantages/risks/influencing parameters and this in relation to the type of substrate. This can end up in a matrix where a planner can select an adequate method."*
***Answer**: We were unfortunately unable to figure out how to do this.*

*One panellist commented that "it is absolutely essential that the controlling of the [conservation] works is performed by skilled and trained technicians, ideally on a daily basis".*
***Answer**: We of course agree and took this comment as an emphasis on the importance of control.*

*One panellist commented that "when cleaning can't be achieved or is too dangerous, one could think about patination - to blend the disturbing area in the whole of the surface" (comment left under the Aggressiveness factor)*
***Answer**: This comment points to a way of dealing with situations of "High" or "Very high" risks. This could be a possibility but certainly others could be added. This subject was not considered as sufficiently mature to be included in this phase of the project and is therefore not tackled here.*

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**Examples of application of the Built Heritage Cleaning Incompatibility Risk Assessment Procedure [Not to be included in the final version of the Procedure]**

Validating the Cleaning incompatibility risk assessment procedure also entails its testing resorting to case-studies. Some examples of application are presented below which correspond to brief descriptions of cleaning interventions that were considered well planned and executed, and that benefited from scientific consultation along the process. These examples, albeit brief, may give an idea of the references used in defining some of the classifications proposed throughout the procedure and, hopefully, make it more palpable.

- **Cleaning of a dense limestone sculpted plinth plus pavement ensemble listed as National Heritage:**

The substrate is a good quality white dense limestone, with an open porosity value below 1%. The surface was in a good condition, but presented different soiling problems and, especially, different significance features that prompted a division into two areas: a heavily sculpted plinth and pavement of virtually plain stone slabs.
The plinth was cleaned resorting to water mist (M1); microabrasion of some areas with alumina particles (M2); poultices with a 1.5% solution of tetrasodium EDTA (M3) in some areas.
The cleaning of the pavement resorted to the same methods, plus acid cleaning in very restricted areas (M4) and neutral soap (M5).

**Plinth**

| Vulnerability (A) | Aggressiveness (B) | Synergies (C) | Likelihood (AxBxC) | Significance (D) | Incompatibility risk classification |
|---|---|---|---|---|---|
| 1.2 | M1 = 1 | M1 = 1 | M1 = 1.2 | 5 | Medium |

| | | | | | |
|---|---|---|---|---|---|
| | M2 = 6 | - | M2 = 7.2 | | High |
| | M3 = 5 | M3 = 1.5 | M3 = 9 | | High |

**Pavement**

| Vulnerability (A) | Aggressiveness (B) | Synergies (C) | Likelihood (AxBxC) | Significance (D) | Incompatibility risk classification |
|---|---|---|---|---|---|
| 1.2 | M1 = 1 | M1 = 1 | M1 = 1.2 | 2.5 | Low/Very low |
| | M2 = 6 | - | M2 = 7.2 | | Medium/Low |
| | M3 = 5 | M3 = 1.5 | M3 = 9 | | Low |
| | M4 = 5 | M4 = 1.9 | M4 = 11.4 | | Medium/Low |
| | M5 = 1.3 | - | M5 = 1.6 | | Low/Very low |

The tables show that most cleaning options for the pavement are relatively low in risk and, therefore, would allow for a more relaxed management of the 'Quality components'. The plinth, however, shows 'high' and 'very high' risk cleaning options, which means that a detour from a careful planning of the 'Quality components' would easily cause risks to become 'extreme'. This goes to show that, even in objects with fairly sound surfaces and apparently simple cleaning, localized areas of high risk may occur, and adequate expertise and resources must be planned for and allocated.

- **Cleaning of limestones columns in a National Heritage Romanesque Cloister**

The columns were carved from a medium porosity white oolitic limestone. The surface was in very poor condition, presenting active detachment of stone grains.
The cleaning was achieved with laser (M1), biocides (M2), gentle brushing (M3) and water mist (M4).

| Vulnerability (A) | Aggressiveness (B) | Synergies (C) | Likelihood (AxBxC) | Significance (D) | Incompatibility risk classification |
|---|---|---|---|---|---|
| 5 | M1 = 1 | - | M1= 5 | D = 5 | Medium/High |
| | M2 = 1 | - | M2 = 5 | | Medium/High |
| | M3 = 2 | - | M3 = 10 | | High/Very high |
| | M4 = 3 | M4 = 1.7 | M4 = 25.5 | | Very high |

Both the high significance and the extreme vulnerability of these columns forced the choice of the mildest of cleaning methods, but even those presented risk levels that had to be dealt with through careful planning and expertise, so that no increased risks would cause the irreversible loss of stone material.

## *Third Round*

### Document 4: Second Round Results Report

**Delphi Second Round Questionnaire Results**

This document contains the results and discussion of the Second Round of the Delphi debate and is for your information only. There are no questions that need answering, only a report of the previous round, to be consulted as the Panellists deem necessary.

Following the structure of this previous round, the Panellists' answers and comments are presented in distinctive tables, which also include the questions asked. Please note that many questions have been edited in order to provide context, since the comments and answers that the questions referred to were deleted, so that the document would not be excessively long.

Except where otherwise indicated, comments belong to the Panellists who answered 'No' to the question being asked.

**Factor A – Vulnerability to Cleaning: Delphi Debate**

| **1. Do you agree with the changes to the introduction to Factor A – Vulnerability?**<br>*Yes=13*<br>*No=2*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 7***<br>[Yes] *but... one of the categories seems like a miscellaneous container with artificial materials and rocks and it is unclear why it is a group.* |
| ***Panellist 13***<br>*I think mortars are very vulnerable for cleaning, for this I would put them with values of 4 and 5.* |
| ***Panellist 15***<br>*As I understand the table, you're proposing a vulnerability range into which these stone types should normally fall - with the assessor providing a value on the basis of their assessment of surface condition. This is broadly fine, but will you provide guidance on what you consider the condition of a Level 2 Marble vs. a Level Marble? Or would that be left up to the judgement of the assessor?* |

**Answers to Panellists**

Regarding the artificial materials and stones, these were grouped on the grounds that they could present very diverse surface conditions and be classified anywhere between 1 and 5 in terms of Vulnerability to Cleaning. We however acknowledge that this grouping could be misleading and separated the materials.

As for the mortars, we do feel that some mortars are very resistant, and that limiting them to classifications of 4 and 5 would be excessively prudent (see also the comment to question 6).

Regarding the guidance to the surface condition assessment, all the guidance that is provided is in the introduction to the table and table Guidelines. The judgment of the assessor plays a part in the assessment and we merely tried to frame it and prevent graver misjudgements by imposing certain minimum limits for the appraising of more fragile substrates.

| **2. Do you agree with deleting the decay signs describing the surface condition from the 'Guidelines' section of the table?**<br>*Yes=13*<br>*No=2*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 5***<br>*In the first 'round questionnaire' I answered positively (yes I agree) to the scheme proposed for the parameter Vulnerability.*<br>*Now, I'm getting a crucial doubt that could come out in the case you evaluated a great, inevitable, risk* |

*to intervene with a cleaning operation and, consequently, you decide, not to intervene.*
*To better illustrate the dilemma, let's step back.*
*As is well known, in the frame of conservation-restoration, both conceptually and operationally, cleaning (particularly in the case of stone artefacts) assumes a complex meaning, very far from the meaning that the word cleaning has in everyday life.*

*Given the above, in the frame of conservation-restoration, cleaning has two main goals:*
*Goal 1 - removing from the surface deposits (*) that, whatever their nature, disfigure or falsify the appearance (**) of the art-work surface, independently from its significance.*
*(*) deposits is a too general word because it can imply many different types of 'materials' to be potentially removed, such as actual deposits of atmospheric particulate more or less compact, biological patinas, natural mineral patinas (oxalates), previous protective treatments chromatically altered, etc., etc.*
*(**) or, more generally, 'all those values that affect the appearance': aesthetic, historical, religious values, natural not pathological signs of aging, etc.*
*Goal 2 - However, we have not to forget a second (but probably more important) goal of cleaning: 'the removal of any presence of foreign materials (see those listed in previous note (*), to which, the soluble salts should be added) that can determine a great instability of the chemical-physical-mechanical condition of an object surface.*

*According to the general design of the questionnaire it could emerge that the higher is the risk of a cleaning operation (in relation to the different parameters taken into account: vulnerability of the lithotype, aggressiveness of the method, etc.), the more it is unwise to decide the 'execution of cleaning'.*
*Let us suppose to have carefully evaluated all the parameters (vulnerability, etc.) and to have assessed to be, inevitably, in the situation of a very high risk of intervention. This result would induce to decide not to clean (the risk is too high). At the same time we are perfectly aware that the actual chemical-physical-mechanical conditions of the object are clearly unsustainable. This means that we are precisely in the opposite situation: whatever the risk, the removal of the causes of decay (through a cleaning operation) would, in any case, improve the situation of the object surface, not in function of the 'significance' of the object, but precisely in order to preserve, at any cost, the object.*
*This is the dilemma.*

***Panellist 9***
*I agree only partly because visual inspection and pre-diagnosis should, somehow, be parameterized. On the other hand, I know that would mean huge matrices that would never cover all existing damage, alterations and deterioration mechanisms. But, since we not always have porosity data at hand, then I suggest unfolding this factor somehow, or insert the option of not knowing the stone porosity. This is the reality in a country where diagnosis is not always done in its entirety.*

**Answers to Panellists**
Regarding the dilemma presented by Panellist 5, we would like to clarify that, as highlighted in the second paragraph of the introductory section, this procedure does not allow choosing between cleaning or not, since we found deposit impact assessments to be too contingent to permit an assessment procedure to be designed.
It is, of course, quite possible that the application of the current procedure yields an ‘Extreme’ risk result which is still less dangerous than leaving the deposits to further deteriorate the object, but that specific analysis was not the goal of this procedure. The actual goal of the Procedure presented to this Delphi Panel was to provide its prospect user with a tool that identified risk sources and highlighted ways in which this risk could be minimised or mitigated, namely by running it with different cleaning methods and planning for ‘Quality components’, which may be decisive to the success of a heritage cleaning intervention.
Therefore, the dilemma that the Panellist mentions will still have to be dealt with in a case-by-case basis, as presently we do not see how to frame the assessment of the risk of different deposits in a procedure akin to the one proposed to this Panel.

As for the comment regarding the parameterizing of ‘visual inspection’ and ‘pre-diagnosis’, we are unsure about what the Panellist means. On the one hand, both a visual inspection and an assessment of the surface susceptibility to solicitation are necessary in order to rate the Vulnerability of the surface to Cleaning; on the other hand, we find that prescribing limits and/or classes to classify the different

phenomena that may occur on the myriad of substrates and different conservation conditions would not only restrict the applicability of the procedure but would eventually be found inadequate.
The porosity grouping is a guideline to help users to find the appropriate rating and not a work specification. It works as a grouping divider for some stone types, but even if the user does not know the porosity values, he/she will still nevertheless be able to rate the situation by directly assessing the surface condition in terms of being more or less vulnerable.

| ***3. Do you agree with not following the suggestion of subdividing substrates further into different surface conditions?*** *Yes=13* *No=2* **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 7*** *I understand the difficulties, but the emphasis on porosity/lithology type (of the original material) and the conservation condition left without a minimally objective assessment appear as weak points to me. The consideration of another factor (conservation condition) would resolve the matter.* |
| ***Panellist 9*** *For the same reasons of the previous topic.* |

**Answers to Panellists**
Panellist 7 suggests that a tight parameterization should be prepared for each of the 1 to 5 rating classes, for each substrate. We consider that such a proposal would impose our own subjective evaluation to situations and users under the most diverse of circumstances. It seems more reasonable to us that it should be the user defining the classes using their own criteria, and so it was our choice to introduce some references that may help the users, but to not impose a possibly not entirely applicable reality on them.

| ***4. Do you agree with not following the suggestion of adding a surface texture parameter under Vulnerability?*** *Yes=12* *No=3* **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 4*** *Polished sound substrates can be less vulnerable, but then the perception of gloss plays a huge role. What is the correct gloss and if you clean an area in a polished surface there is a risk by cleaning that part it will become dull – so in the end it will become more visible. So polished sound glossy surfaces should be treated also with extra care not to loose the gloss.* |
| ***Panellist 5*** *A short comment. Not always cleaning improves the stability of a monument surface. For example, consider the case of cleaning by sand-blasting. In general, this kind of cleaning increases surface micro-roughness and this makes the object more vulnerable. Not by chance, after an intervention by sand-blasting, almost always a consolidating treatment of the surface is recommended. In another case - cleaning of gypsum black incrustations by laser - after the application of laser, gypsum in the incrustation is removed but not gypsum penetrated in the internal pores close to the surface. You need a second 'cleaning' - for instance, with anion exchange resins - to remove this second foreign presence. The removal of gypsum in the black crust, meets an aesthetical aim, while the removal of gypsum penetrated inside, meets a conservation aim.* |
| ***Panellist 11*** *I think "polished sound substrates are slightly **more** vulnerable than unpolished sound substrates"* [quote is from the 2nd round Questionnaire, where the Panellist replaced "less" with "more"] |

**Answers to Panellists**
Three Panellists disagree with not considering surface texture, and namely the influence of polishing. While we still believe that these issues represent a refinement in terms of Vulnerability analysis, these

remarks led us to propose that the presence of polished surfaces constitutes a Synergy that should be considered when analysing any method; edits were made to the Synergies table accordingly.

| ***5. Do you agree with all of the added substrates?*** <br> ***Yes=14*** <br> ***No=1*** <br> **Consensus reached** |
|---|
| ***Remarks*** |
| ***Panellist 7*** <br> [Yes] *I suggest adding 'ultramafic, gabbro'. I believe that serpentinites are missing - there is a lot of serpentinite in Europe* |
| ***Panellist 13*** <br> [Yes] *But you can´t talk any more of stone heritage conservation.* |
| ***Panellist 15*** <br> *Adding mortars and renders is not helpful - if you introduce mortars then you will need to differentiate between different types (lime, gypsum, natural cement) & sub-types (e.g. for lime, CL90, NHLs, lime/pozzolanic mixes). This is a separate thesis, and not a helpful comparison for stone cleaning.* <br> *Adding brick & concrete is similarly not helpful, and does not help with your assessment procedure.* |

**Answers to Panellists**
In view of the comment from Panellist 7, "gabbro and similar rocks" was added to the 'Basalts' table entry.

We would also like to draw attention to the fact that the procedure is to be used for Built Heritage Cleaning, and therefore should try and encompass other elements that may be present, such as tiles, brick or concrete – and mortars and renders.

Regarding the comment from Panellist 15, we agree that mortars are extremely complex and variable materials, but not necessarily more complex than each of the groups of lithotypes listed in the Vulnerability table. We believe that, in terms of vulnerability to cleaning, they may (and should) be assessed and rated.

| ***6. Do you agree with the rating scales for the added substrates?*** <br> ***Yes=13*** <br> ***No=2*** <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 7*** <br> [Yes] *but suddenly (in the added groups), porosity (which was the distinctive criterion) disappeared.* |
| ***Panellist 8*** <br> *It seems to me not useful to have the same rating scales for all the added substrates (Brick masonry, Ceramic materials, Concrete, Basalt, Porphyry, High grade metamorphic rocks), which are very different from each other both for the porosity characteristics and for the chemical/mineralogical ones.* |
| ***Panellist 15*** <br> *Mortars & Renders, if to be included, can be anywhere 1-5 on the scale.* |

**Answers to Panellists**
Following our comment to question 3, we would like to highlight that porosity was used as a grouping criterion (which further allowed imposing some minimum rating values), but it is a criterion that does not function equally well for all substrate types as indicator of their vulnerability.
On the other hand, we entirely agree with the comment by Panellist 8, and followed it by separating the mentioned substrates into different table entries.

Finally, regarding the ratings for mortars and renders, we added a note to the Vulnerability table mentioning the cases of exceptionally resistant materials featuring hydraulic binders. We do, nevertheless, still believe that, for most cases, mortars and renders are too susceptible to be rated below 3.

| **7. Do you agree with not adding adobe or alabasters?**<br>*Yes=13*<br>*No=2*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 4***<br>*I can imagine that alabaster is not the most common building stone, but sometimes it was used and has specific water sensitivity. It can be cleaned with water under strict guidance and timing. An interesting stone type to add I think.* |
| ***Panellist 7***<br>*adobe yes alabaster no* |

**Answers to Panellists**

We believe alabaster to be mostly used for decorative elements, and rarely found in architectonic surfaces. However, following this perspective, we did find it could be useful to add "gabbros and similar rocks" (see Question 5).

| ***8. Do you agree with the subdivision of granites into two porosity categories?***<br>*Yes=14*<br>*No=0*<br>*N/A=1*<br>**Consensus reached** |
|---|
| ***No comments were made.*** |

| ***9. Do you agree with not following the suggestion of introducing pore size and interconnectivity as parameters due to the complexity of measuring and interpreting them?***<br>*Yes=14*<br>*No=1*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 3***<br>*To postulate a correlation between vulnerability of a surface and porosity is very problematic and this correlation is not a general rule. For example, the Obernkirchner Sandstone is one of the most resistant sandstones in Germany though its porosity is close to 20 Vol%. More important than the number of porosity is the grain size distribution. If the grain size is coarse and the grain size distribution is very homogeneous, then a correlation between porosity and vulnerability should exist. I would suggest raising the upper limit to 20 %. Nevertheless the ratings shown in the table above should not be seen as irreversible. A stone with a porosity > 20 % can also be classified with rating 1.* |

**Answers to Panellists**

We agree that, for some particular sandstones, such as the one mentioned in the comment above, the porosity is not an accurate indicator of the substrate vulnerability, and therefore a note was added to the table mentioning these specific cases. Regarding raising the porosity upper limit to 20%, we did not follow this suggestion because of the feedback already given in the First Round Questionnaire, where most Panellists agreed with the 15% limit.

| ***10. Do you agree with not following the suggestion of adding a class for stones with porosity extremes (> 35%)?***<br>*Yes=13*<br>*No=2*<br>**Consensus reached** |
|---|

| ***Comments*** |
|---|
| ***Panellist 3***<br>*See comment above* [to question 9]. *Porosity limit 20 %.*<br>*General comment: you wrote ratings between 4 and 5, the highest possible ratings. High rating - low resistance isn't this a contradiction in itself?* |
| ***Panellist 8***<br>*Stones with a porosity higher than 35% react to the different decay factors in a way different from a stone whose porosity is around 15%.* |

**Answers to Panellists**

The porosity upper limit was defined in the previous round where, given the opinions of the Panellists, we ruled a consensus at 15%. Of course we agree that a 35%-porosity stone reacts differently to decay factors than one with a 15% porosity, but, as previously explained, the rating ranges for these stones are already the highest possible ratings, and therefore there is no room for a new group.

As for the "high rating-low resistance" apparent contradiction, the terms simply mean "higher rating = higher risk probability".

| ***11. Do you agree with not following the suggestion of changing the rating ranges from 1-5 to 1-3?***<br>***Yes=15***<br>***No=0***<br>**Consensus reached** |
|---|
| ***No comments were made.*** |

| ***12. Do you agree with not following the suggestions of: (a) make all substrates that start at 1 to start at 2; and (b) medium sandstones starting at 3?***<br>***Yes=15***<br>***No=0***<br>**Consensus reached** |
|---|
| ***No comments were made.*** |

| ***13. Do you agree with not following the suggestion for renders to start at 2?***<br>***Yes=13***<br>***No=2***<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 13***<br>*See comment above* [to question 1]. |
| ***Panellist 15***<br>*This may be the case in Portugal but is not the case in other countries. Historic mortars can be more durable than stone, and it would be short-sighted to assume they are inherently "vulnerable".* |

**Answers to Panellists**

Please see comments to questions 1 and 6.

| ***14. Do you agree with (a) marbles rating starting at 2; (b) dense limestones starting at 1; (c) surface morphologies being dealt with under the Significance factor?***<br>***Yes=15***<br>***No=0***<br>**Consensus reached** |
|---|
| ***No comments were made.*** |

**Factor B – Aggressiveness: Delphi debate**

| ***15. Do you agree with the added methods?***<br>***Yes=13***<br>***No=3***<br>**Consensus reached** |
|---|
| ***Comments***<br>***(One panellist chose both 'yes' and 'no', but left no comments)*** |
| ***Panellist 9***<br>*I think that dry ice should not even be considered as an acceptable method for conservation. Then I wonder why not add very high pressure values to the table, e.g. values above 5 or 10MPa, which are also not at all acceptable?* |
| ***Panellist 11***<br>*Vacuum cleaner is a "hand hold tool" but not a "hand tool"* |
| ***Panellist 13***<br>[Yes] *But I think it's important to write about the application method of the chemical methods. This has a big influence on the rating.* |

**Answers to Panellists**

We refer the comment about the dry ice method to the Aggressiveness Table Guideline stating that "Dry ice blasting should be considered as a microparticle jet (where the particles are solid $CO_2$)"; and to the First Round comment from Panellist 8: "For the moment [dry ice] is a method used for industrial cleaning, but it seems to be promising also in the field of cultural property. It was tested with positive results for an archaeological marble monument in Rome (Caius Cestius' Pyramid) and is now being used for the ancient walls in Barcelona." (See First Round Answers Report)

Regarding the 'vacuum cleaner' note, we agree and removed it from the 'Hand tool' table entry; we furthermore considered that vacuum cleaners are seldom used on their own, and are more often a complement of other tools to eliminate residues that were already removed from the object.

As for the influence of the application method on the aggressiveness of chemical cleaning agents, although accepting in theory that an influence may exist, we were unable to figure out how could the different possible application methods be scaled in this system, considering that controllability is already included as a guiding concept.

| ***16. Do you agree with their respective ratings?***<br>***Yes=13***<br>***No=1***<br>***N/A=1***<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 5***<br>[Yes] *Not completely, particularly regarding 2 items: alkaline agents and chelating agents. In the questionnaire, the alkaline agents are rated strong when pH is > 9. In reality, calcium carbonate (i.e. the carbonatic stone materials) is stable up to pH 11 (its water solubility decreases - so its stability increases - from pH 7 to 11) and most of the silicate stones are stable up to pH 11. In other words an upper limit '9' seems excessively prudent. As far as the chelating agents, as already said in previous round, in the case of EDTA agents, we have to distinguish: while Na4EDTA is generally enough safe, Na2EDTA, on the opposite, is very aggressive. Its ranking could be higher than '7'.* |
| ***Panellist 11***<br>*Vacuum: specify what is meant here.* |

**Answers to Panellists**

Following the comment by Panellist 5, the upper pH threshold for 'Strongly acidic or alkaline reagents' was raised to 11. On the other hand, the upper limit of the rating range for 'Chelating agents' was raised to 8, and a note was added drawing attention to the pH of chelating solutions.
The 'vacuum cleaner' table entry was removed.

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| ***17. Do you agree with not following the suggestion of adding a class specifically for 'Biological methods' and only making a note in the 'Guidelines'?***<br>*Yes=12*<br>*No=2*<br>*N/A=1*<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 7***<br>*Ultimately the consideration is true, but there is a very relevant aspect ... With a chemical produced by a living agent, its production carries on with time and if the number of individuals increases, the produced amount increases. It is therefore very different from adding a man-made chemical. And there is the risk of altering the micro-ecosystem. I don't know specifically what the suggestion would entail, with the difficulty of identifying the products in a simple way; it is a complex but very present issue.* |
| ***Panellist 11***<br>*In this "broad approach" which I do not agree on, laser could also be considered as a type of "chemical cleaning" method as the dust is "chemically" destroyed through the impact of the laser source* |

**Answers to Panellists**

We understand the objections made, but to proper rate bacterial cleaners bearing in mind the issues raised by the Panellist would require a micro-ecosystem study for each particular object and object-cleaning agent combination, making it too complex and too contingent to include in this Procedure.
On the other hand, we consider that laser cleaning is a method with its own specificities and we have an alternative parameterization for it, which we don't have for biological methods. Furthermore, we don't see any benefit arising from merging laser cleaning with chemical methods.

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| ***18. Do you agree with changing the ratings for hand tools (stretched to 6) and laser (widened to range between 5 and 10 above ablation threshold but kept between 1-1.5 below ablation threshold)?***<br>*Yes=13*<br>*No=2*<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 3***<br>*Discoloration of iron hydroxides (limonite) already takes place below the ablation threshold. I would insert a third parameter line: coloured sandstones and limestones. Change the other parameters to "white or grey sandstones and limestones below ...." And "white or grey ……… above ablation threshold".* |

**Answers to Panellists**

In view of the Panellist comment, we added the considering of 'discolouration' to the Aggressiveness table entries pertaining to laser assessment. This implied that the parameter related to the 'discolouration' of minerals in the Synergies table was no longer necessary, and therefore that parameter was removed.

| |
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| ***19. Do you agree with the following changes: (1) include features such as shape or density in the particle jet class; and (2) adding pH ranges for the chemical cleaning solutions class?***<br>*Yes=14*<br>*No=1*<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 5***<br>*See my previous comment about pH of chemical agents.* [question 16] |

**Answers to Panellists**

Concerning the pH of chemical agents, please see comment to question 16.

We would furthermore like to add that, regarding particle jet, a note was added to the table Guidelines to clarify particle density classification.

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| ***20. Do you agree with not following the suggestion of rating chemical methods more conservatively (because of the cases where no scientific consulting is available), an issue we considered was more appropriately dealt with under 'Quality components'?*** <br> ***Yes=14*** <br> ***No=1*** <br> **Consensus reached** |
| ***Comments*** |
| ***Panellist 9*** <br> *Perhaps this perspective is valid for countries where conservation is always preceded by scientific advice in the diagnostic phase. In my country, it is the exception to the exception, for the field of conservation sciences dedicated to the built heritage is just beginning. In the directory of the National Centre for Scientific and Technological Development there is no conservation sciences category.* |

**Answers to Panellists**

We still believe that concerns about the lack of scientific consulting may be appropriately addressed under 'Quality components'.

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| ***21. Do you agree with not following the suggestion of narrowing the Aggressiveness rating ranges from 1-10 to 1-5?*** <br> ***Yes=15*** <br> ***No=0*** <br> **Consensus reached** |
| ***No comments were made.*** |

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|---|
| ***22. Do you agree with not following the suggestion to add 'dwell time' to the chemical methods since, at the end of the day, it is a question of potential of damaging energy or controllability?*** <br> ***Yes=12*** <br> ***No=3*** <br> **Consensus reached** |
| ***Comments*** |
| ***Panellist 5*** <br> *Nevertheless there are exceptions. Some chemical methods, to be truly effective, require long contact times. Their safe behaviour is an intrinsic quality: it depends on the selective nature of the agent and its application protocol, not on contact time.* |
| ***Panellist 7*** <br> *Even if it is generally contemplated, it would not be the worse to specify it for this case.* |
| ***Panellist 13*** <br> *See comment above* [to question 15] *and I think chemical methods have to be more differentiated, because there are too many options to use them.* |
| ***Panellist 15*** <br> [Yes] *In English-language text, this is normally referred to as 'dwell time'* |

**Answers to Panellists**

We agree with the comment from Panellist 5, which we think corroborates our reasoning.

As for the comment by Panellist 7, we still find that dwell or contact time is as important for chemical methods as is for other kinds of methods. In all instances, either this time is excessive – due to poor controllability or high potential of damaging energy or malpractice – or isn't, and hence adding a new parameter seems redundant.

Regarding the differentiation of chemical methods, please see our answer to question 15.
Finally, the term 'permanence time' was replaced by 'dwell time' where applicable.

| ***23. Do you agree with the explanations offered for keeping both 'controllability' and 'potential of damaging energy' as concepts to assess Aggressiveness?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
|---|
| ***No comments were made.*** |

| ***24. Do you agree that 'potential of damaging energy' may be used for chemical methods?***<br>*Yes=14*<br>*No=1*<br>**Consensus reached** |
|---|
| ***No comments were made.*** |

| ***25. Do you agree with our reasoning that an Aggressiveness assessment may be achieved and complemented by the method/substrate interactions described by the Synergies assessment?***<br>*Yes=14*<br>*No=0*<br>*N/A=1*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 11***<br>[N/A] *Unclear* |

**Answers to Panellists**

The comment raises an answering difficulty: it is not clear for us exactly what is "unclear" for the Panellist: our explanation in the previous round, or the Procedure? With the Procedure validated by the other Panellists, we assume that the unclearness relies in our explanation.

Our departing objective is to get a value for the Aggressiveness of a given method. We all know that this depends on the cleaning tool, on the process to use it, on the operators' skills and on the substrate. Basically we have two options to reach this objective: i) to build up an extensive matrix with all possible combinations, and ii) to use an algorithm that works with key-components of this complex problem. Having chosen the latter, this was materialised as follows: i) the "intrinsic" potential aggressiveness of the method is tackled in factor B; ii) the dependence on the substrate was tackled in two ways: an "intrinsic" component (factor A) and an interactive dependence (factor C). We furthermore postulated that this algorithm implies that the method is applied by a skilled and well-informed operator. Should this be the case, the algorithm ends here; any doubts or issues related with operators' skills that may supervene are considered risk enhancers and tackled as "Quality components".

We hope this is clearer now.

| ***26. Do you agree with replacing 'energy density' with 'potential of damaging energy'?***<br>*Yes=13*<br>*No=2*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 7***<br>*The suggestion* ['potential for adverse impact on stone', suggested to replace 'energy density'] *was not mine, but it seems better than "potential of damaging energy".* |

**Answers to Panellists**

Given the approval of most Panellists, we kept the term 'potential of damaging energy'.

| ***27. Do you agree with the explanations offered regarding the option of presupposing operator competence and skills in the Aggressiveness assessment and addressing those issues in the Quality*** |
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| ***components section?*** <br> ***Yes=15*** <br> ***No=0*** <br> **Consensus reached** |
| ***Comments*** |
| ***Panellist 9*** <br> [Yes] *But I think this research should mention that the assessment of the experience / skills of the operator should be the object of another research / matrix. I know it is difficult to insert it here.* |
| ***Panellist 13*** <br> [Yes] *I agree with the problem of evaluating the operator skills. But, because in my country there are no trained persons, for that all methods have to be at the end of the rating bar at 10, independently of the beginning of the rating bar.* |

**Answers to Panellists**

The comments illustrate a situation where the training of operators is undervalued and needing strong pushes to be improved. As these panellists realize, this is out of the scope of the present methodology.

| |
|---|
| ***28. Do you agree with the changes to the Introduction of this section?*** <br> ***Yes=15*** <br> ***No=0*** <br> **Consensus reached** |
| ***Comments*** |
| ***Panellist 7*** <br> [Yes] *There seems to be a contradiction... "minimum risk" and "potential of damaging energy"...* |
| ***Panellist 13*** <br> [Yes] *If it not includes the red comments.* |
| ***Panellist 16*** <br> [Yes] *Very useful.* |

**Answers to Panellists**

We were unable to find the text with the contradiction mentioned by Panellist 7. In any case, we opted to change "minimum risk" to "baseline risk" hoping this wording might solve the existing doubts.
On the other hand, we should point out that the 'red comments' constitute the changes on which we asked for the Panellist opinion, so we are assuming that Panellist 13 disagrees with these changes, although the comment is not specific enough for us to answer. Therefore the consensus was reached with 14 'Yes' and 1 'No'.

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| ***29. Do you agree with clarifying the cases of combined cleaning methods?*** <br> ***Yes=15*** <br> ***No=0*** <br> **Consensus reached** |
| ***No comments were made.*** |

**Factor C – Synergies: Delphi debate**

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|---|
| ***30. Do you agree with the changes to the Introduction of this section?*** <br> ***Yes=15*** <br> ***No=0*** <br> **Consensus reached** |
| ***Comments*** |
| ***Panellist 13*** <br> *But in the section 'Any method requiring water' must be included the effect of water on the growing of* |

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| *micro-organisms.* |

**Answers to Panellists**
A warning to this possibility was introduced in the Aggressiveness factor.

| |
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| ***31. Do you agree with not following the suggestion of adding mechanical methods to the Synergies table on grounds of their high dependence on operator skills, which are addressed under 'Quality components'?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
| ***No comments were made.*** |

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|---|
| ***32. Do you agree with the following changes to Synergies table: replacing (1) 'marbles when using steam' by 'substrates sensitive to temperature fluctuations when using steam'; and (2) 'Reactive with the substrate' by 'Causing chemical degradation/ decomposition'? Further, do you agree with not considering 'Formation of stains/salts' a Synergy parameter because of it not depending on the substrate?***<br>*Yes=15*<br>*No=1*<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 7***<br>[Panellist chose both 'yes' and 'no']<br>*With the changes yes, but not with some of the explanations:* [the formation of stains / salts] *may well depend on the substrate.* |
| ***Panellist 11***<br>*I do not agree with "the 'Formation of stains/salts' is not a synergy, since it does not depend on the substrate".* |

**Answers to Panellists**
The formation of soluble salts is now introduced as a possible Synergy, although we could not figure out a good example to materialize it.

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|---|
| ***33. Do you agree with (1) not following the suggestion of adding 'the presence of black crusts and/or old treatments' as parameters (because no synergetic effects ensuing from these were identified); and (2) replacing "Water-based methods" with "Any method using water"?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 7***<br>[Yes] *but the listing could still be improved.* |

**Answers to Panellists**
We introduced some minor adjustments that we consider to have improved the Synergies table.

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|---|
| ***34. Do you agree with the proposed ratings for the Synergies factor?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
| ***No comments were made.*** |

| ***35. Do you agree with keeping the Synergies assessment range between 1 and 2?*** <br> ***Yes=14*** <br> ***No=1*** <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 3*** <br> [Yes] *The suggestion of the panellist* [of rating Synergies between 1 and 3] *is not reasonable. An increment factor of 2 enhances the risk by 100 %, a factor of 3 by 200%. 100 % already includes the whole range the risk can increase.* |
| ***Panellist 5*** <br> *If the alternative to exclude 3 levels is to articulate the range between 1 and 2 with intermediate values, such as 1,2  1,3  etc., then, perhaps, it would be better to decide for simply 1  2 and 3.* |

**Answers to Panellists**
We would like to point out that fraction/decimal ratings are valid throughout the Procedure, and not only for Synergies.
As for the maximum value for Synergies, a factor that was formulated as an increment of its two preceding factors, a rating of 3 would be excessive and could introduce biases when comparing different methods.

| ***36. Do you agree with adding a sentence regarding the importance of both short-term and long-term synergistic impacts?*** <br> ***Yes=15*** <br> ***No=0*** <br> **Consensus reached** |
|---|
| ***No comments were made.*** |

**Additional note**
Two Panellists made comments (directly) on the laser table entry in the Synergies factor; more specifically, the comments were related to the "polymineralic stone" phrase and are quoted and answered below.

> **Panellist 7**
> [Replace "polymineralic stones" with] "stones with minerals of different colours".
>
> **Panellist 16**
> "Or polymineralic stones": I wonder why you added this specification. First, what are polymineralic stones? All stones are polymineralic, aren't they? Moreover, the interaction of lasers with stone – not with patinas or other substances that are NOT stone – is a still debatable issue."

**Answers to Panellists**
Given the comment of Panellist 3 to Question 18, we believe that potential discolouration damage inflicted by laser would be more aptly considered as an Aggressiveness component, and therefore eliminated this entry altogether from the Synergies table. We agree with Panellist 16 that other substances that are not stone may be involved, and think that this possibility is now covered by considering laser discolouration in the Aggressiveness factor.

**Factor D – Impact on Significance: Delphi debate**

| ***37. Do you agree with adding a Guidelines note to draw attention to ornamented/plain dichotomies, instead of replacing the terms "high/low significance"?*** <br> ***Yes=13*** <br> ***No=1*** <br> ***N/A=1*** <br> **Consensus reached** |
|---|
| ***Comments*** |

***Panellist 3***

This panellist made several comments in distinct parts concerning the factor "Impact on Significance". For easier analysis these comments were grouped here.

*- The distinction ornamented/plain surface is better than high/low relevance.*
*- Irrespective a listed or a non-listed object the surface is always most relevant, if it determines its appearance, reflects its history, the techniques used for its production. The surface is the identity card of an object, it never must be altered by any cleaning method. Altering the surface would mean to alter the value.*
*- Significance for what? If you go deeper into the meaning of significance you will notice that "simple plain" surfaces may have the same significance as decorated ones. See also below the term high/low relevance. Relevance for what?*
*- Listing status was mainly introduced to determine the institutions which are responsible and have to be asked if restoration work is being planned. Category 1 needs governmental authorities, category 2 regional, category 3 local authorities. Irrespective of category all measures have to be carried out with the necessary carefulness to exclude any harm to the object.*
*In practice we often see that the appearance of simple wall ashlars without particular features is totally altered by inadequate measures. So the historic importance of a simple stone wall can be totally destroyed.*
- *I doubt this conclusion* [formal aspects such as the presence of sculpted work, carvings or other decoration patterns are generally associated with higher relevance; plain ashlars or rubble masonry may be comparatively (though not necessarily) less relevant for the significance of the object]. *Why are the ashlars in a wall simply plain? Wasn't designed by purpose?*
*My opinion is that all surfaces always must be cleaned with the most careful method which does the minimal or better no harm to the surface.*

**Answers to Panellists**

We find that the distinction "ornamented/plain surface" may cause some misjudgements on the assessment of the importance of different surfaces. As the Panellist mentions in several comments (quoted above), plain ashlars are part of the building design, and "«simple plain» surfaces may have the same significance as decorated ones".
On the other hand, we disagree that "the surface… must never be altered by any cleaning method" – cleaning will always alter the surface or, at the very least, the evolution of the surface from the cleaning moment onwards. We do agree that "Altering the surface would mean to alter the value" and this is why we proposed that the consequences of cleaning be assessed resorting to an 'Impact on Significance' factor. In this context, 'relevance' refers to the significance of the object, and namely how relevant is the surface material to the significance of the object.
Furthermore, we would like to emphasise that giving this guideline for assessing the "Impact on significance" doesn't imply that this is the unique criterion to use, rather on the contrary, the user is supposed to use whatever criteria he/she is able to handle to reach a fair knowledge on this factor.

***38. Do you agree with the explanations offered in support of focusing cleaning assessments on surface features and not adding a requirement for cost-benefit analyses?***

***Yes=14***
***No=0***
***N/A=1***
**Consensus reached**

***Comments***

***Panellist 3***
[Yes] *Cost–benefit analysis is an inadequate suggestion. How can or will the panellist measure the benefit?*

**Answers to Panellists**

We addressed this issue in the previous round.

***39. Do you agree with the clarifications to the introduction of this section?***

***Yes=14***

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| ***No=0*** <br> ***N/A=1*** <br> **Consensus reached** |
| ***No comments were made.*** |

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|---|
| ***40. Do you agree with the explanations offered in support of a significance assessment with reference to listing status as a suitable form of evaluating the potential damage consequences of a cleaning intervention?*** <br> ***Yes=12*** <br> ***No=3*** <br> **Consensus reached** |
| ***Comments*** |
| ***Panellist 3*** <br> *I agree with the comment of the panellist* [stating that a significance assessment in this context may open a "Pandora's box"]. *For every object, be it listed or not, the most careful cleaning method must be applied to avoid damage of the surface. Today it is not a problem to clean also huge surfaces with careful method at reasonable price. To save money would mean to use dangerous methods like acidic cleaners or sand blasting. What is when the object which is not listed today will be listed in 30 years?* |
| ***Panellist 9*** <br> [Yes] *But I would like to understand why it is difficult to assess/classify the severity of the damage consequences of cleaning operations. This worries me because in inspections everyday I have to explain why it is harmful to use high-pressure water jets. This happens in contexts of maintenance with unprepared operators (including those in charge of maintenance with no preparation for dealing with listed monuments / unlisted old buildings) and also in contexts of conservation works with operators that are supposed to be (at least minimally) prepared (on-job training: construction workers working in restoration contracts). This is a reality in* [my country]. |
| ***Panellist 11*** <br> *Significance assessment is not only subjective but in some cases also contemporary* |
| ***Panellist 15*** <br> *You can (and should) ignore significance entirely. In practice, the assessment of cultural significance of the object has already occurred before the issue of stone cleaning arises. If it wasn't a historic surface, you wouldn't be paid to assess it. The cleaning and conservation of heritage buildings and monuments usually occurs because it has already been recognised as heritage.* <br><br> *I mentioned Pandora's Box as many buildings are multi-phase, so determining the significance is challenging and multi-faceted. Significance is also often partly or wholly determined by intangible issues outside of the building fabric (e.g. because it is part of a group or series, or because it is a scarce/rare building type, because it is the work of a particular architect, or because a particular historical person or event is associated with the building). It's very helpful to understand the significance of the monument, but it is a separate exercise to determining the impact of cleaning. For example, I had to assess the impact of an unauthorised cleaning of a castle with stone carvings from 1500, the Renaissance & the 18th century all of the same stone type. All three sets of carvings have cultural significance - should one be valued more than another when the key issue is the interaction between the stone & cleaning method(s)? The assessment of archaeological & architectural significance of the building (though already tacitly accepted as a 'listed' monument) was carried out as a parallel activity (coincidentally also by me). BUT the significance of the different elements in a historic building does not (or should not) alter how the stone surfaces should be assessed or they should be cleaned.* <br><br> *Adding in an assessment of significance does not improve the accuracy or reliability of the assessment of impact of cleaning on a stone surface.* <br><br> *However, while I have fundamental problems with adding in significance, I understand you're committed to putting it into your assessment scheme. So, you'll also need to factor in an assessment of whether cleaning will potentially enhance or detract from the significance of the building (even if it cleans without any damage to the stone surface) e.g.* |

*A. The appearance & character of the building will change after cleaning (it may no longer look 'old', will perceptions of its historic value change?)*
*B. The cleaning may remove a uniform soiled facade and reveal a patch-work of past alterations, repairs, etc.*
*C. If the building is part of a terrace or streetscape, how will its new cleaned appearance affect its significance? (grouping & streetscape is an important significance value in many countries)*

**Answers to Panellists**

Panellists 3 and 11 are worried about the time contingency of significance assessments. Time, space and group variations are, indeed, a feature of significance. However, we maintain that this is an inescapable reality of conservation: if we conserve objects because they have value(s), then the preservation of this value is the ultimate goal of any intervention. If we do not know which values we are conserving, how can we plan for their preservation? And how should we evaluate if our actions were positive or damaging? On the other hand, as conservation professionals, we of course must consider both present and future values; but the difficulties in predicting future values cannot hamper our actions today, otherwise, ultimately, no conservation actions would be allowed.

As for subjectivity, we find it overly optimistic to believe that minding material features alone may lead us to a successful and objective conservation intervention: there are always choices (e.g. restoration versus active conservation versus preventive conservation, and then choices within these) and these always have an impact on the evolution of the materials of the object. These choices, even if it is not clearly stated, always depart from value judgements and therefore they may be shared, but they are never objective; they are intersubjective at best.

Although a full significance assessment would be ideal, we do not require it for this Procedure because we realized it would be too complex and deter users. We merely suggest that the user considers the impact of a potential material loss, but the rating system is probably not sophisticated enough to accommodate differences such as the three sets of carvings mentioned by Panellist 15. It is, however, enough to distinguish between, for example, Michelangelo's David and its copy; or between a pavement and a decorated portal. Oppositely to Panellist 15, we argue that different degrees of care (and resources) are put into the cleaning of these different objects.

Still regarding the comments by Panellist 15, we do not see how "Adding in an assessment of significance does not improve the accuracy or reliability of the assessment of impact of cleaning on a stone surface", since we are unable to understand how the impact of cleaning may be measured without a significance assessment.

We do, nevertheless, greatly appreciate the suggestions offered by this Panellist for the significance assessment of objects, but we believe that they refer to the definition of the intended cleaning level, i.e. to a prerequisite of this Procedure.

Finally, and to answer Panellist 9, the mentioned doubts and concerns derive from the difficulty to dialogue with mostly unprepared operators. In such circumstances, it is obvious that discussing about values is useless. Then, an authoritative way is probably best: "The method causes excessive changes and such changes are inadmissible".

***41. Do you agree with the explanations offered in support of the "listed/unlisted or equivalent" criterion?***

***Yes=11***
***No=3***
***N/A=1***
**Assigned consensus**

***Comments***

***Panellist 3***
*Why the significance – listed – non listed issue is introduced into the paper at all? Isn't it much better to not interfere into the problems of classifying monuments? This paper should only deal with the scientific problems of cleaning and the assessment of the respective methods to various surfaces.*

***Panellist 11***
*The aspect "significance" when dealing with cleaning has to be broadly applied, including the environment where the object is located.*

***Panellist 13***
*In* [my country] *the listing of an object is often a political decision, and has nothing to do with the significance of it.*

**Answers to Panellists**

Regarding the objection of Panellist 3, we would like to say that we do not wish to interfere with the classification of monuments – far from it: we merely use it as a widely accepted reference of what we think must be considered when using the Procedure. This way, the assessment is not entirely dependent on user judgement.

Furthermore, we consider that the remark of Panellist 11 does not invalidate the criterion: it reads like a suggestion for a better (more detailed) 'Impact on significance' assessment, and not as a need for an alternative. Expecting to resolve this 'No', we have added one more Guideline to Factor D.

As for Panellist 13, the words "or equivalent" were added to the table, precisely to solve this objection. Without an alternative from the Panellist or an explanation on why this alternative doesn't solve the question, we have to consider this issue as solved.

The answers imply a formal "No consensus", since consensus required twelve instead of eleven 'Yes' answers. This would require a Third Round, but, given the Panellist comments, we face a practical dilemma:

1) Objections from Panellists 3 and 13 concern the inclusion of the 'listed/unlisted or equivalent' criterion; these two objections, considered alone, would configure a Panel consensus;

2) The objection of Panellist 11 concerns the need to include environment on the significance assessment, which we take as an added guideline that does not contradict the proposed scheme;

3) Apparently no more than two 'No' were given to a same argument.

Considering the eleven 'Yes' answers already given and the solution given to the objection of Panellist 11, we think that a Third Round is not justified, even more so considering that no better alternative to harmonize the eleven 'Yes' and the three objections could be delineated.

Based on these judgments, we decided to assign a consensus to the question.

***42. Do you agree with adding a note to the table Guidelines drawing attention to surface morphology, including the presence of decoration?***

*Yes=14*
*No=0*
*N/A=1*
**Consensus reached**

***Comments***

***Panellist 9***
[Yes] *Because otherwise it would overly complicate the use of the evaluation matrix. And, after all, the procedure is always applied in a specific context that one has to take into account. I consider utopian the will to establish a procedure that universalizes all situations, so the more straightforward and objective the procedure, the greater chance it has to be appropriated by those who plan, perform and control interventions.*

**General appreciation of the chosen factors: Delphi debate**

***43. Do you agree with introducing the risk definition in the beginning of the procedure?***

*Yes=15*
*No=0*
**Consensus reached**

***No comments were made.***

| ***44. Do you agree with the explanations offered regarding (1) why the Synergies were separated from Aggressiveness; and (2) why the suggestion to parametrize the 'degree of cleaning' was not followed?*** <br> ***Yes=14*** <br> ***No=1*** <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 5*** <br> *I partly agree with the panellist who would add "degree of cleaning'. Sometimes, depending on the method of cleaning, that does not permit the operator to freely decide the degree of cleaning, sometimes, instead, depending on the professional quality of the operator, the final level reached of cleaning is unjustifiably excessive. This can happen, for instance, when the patina, theoretically 'to be removed' is a calcium oxalate film not excessively colored. In that case cleaning should be preferably stop before arriving to the stone - whatever it is - and is convenient to leave a thin residue of the patina, that has a protective function and, furthermore, is a value (historical acquired value), as a sign of passage of time.* |

**Answers to Panellists**

As stated in our answer on the previous round, we also agree that the degree of cleaning is not entirely independent from the method used to reach it (and we also evidently concur with the importance of maintaining the patina). However, as explained, we were not able to parameterize this suggestion due to its contingency. We presupposed that the target surface (degree of cleaning) is established beforehand and it is non-negotiable: assuming the target surface as a given, we are able to assess the contribution of the different factors (Vulnerability, Aggressiveness, Synergies and Impact on Significance) to the risk of surpassing that target surface.

Establishing this target surface before a cleaning intervention requires analysing (1) the impact of the deposits on the substrate, including influence on stability, significance, authenticity and integrity; and (2) the possibilities and limitations of cleaning methods on that precise substrate/deposit combination, resorting to cleaning tests. Both of these items seem excessively conditional to be properly parameterized or framed.

| ***45. Do you agree with the explanations offered for not adding parameters or a new factor dealing with the risks for the operator and environment?*** <br> ***Yes=14*** <br> ***No=1*** <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 13*** <br> [Yes] *Also a trained operator would mind these safety aspects.* |

| ***46. Do you agree with (i) adding a Guideline considering the permanence of residues; and (ii) the explanations offered on why 'gradual cleaning' is considered covered by the 'Controllability' parameter in the Aggressiveness table?*** <br> ***Yes=14*** <br> ***No=1*** <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 5*** <br> *See my previous comment on gradual cleaning.* [Question 44] |
| ***Panellist 13*** <br> [Yes] *Also, a trained operator would mind the aspects of permanence of residues.* |

**Answers to Panellists**

Regarding the gradual cleaning, please see our comment to Question 44.

Regarding the permanence of residue, the inserted Guideline is a reminder of the importance of considering this aspect.

***47. Do you agree with the explanations offered on: (i) why the suggestions of inserting a methodology validation step and a post-intervention material behaviour assessment were not followed; and (ii) why we consider that the procedure is valid for different kinds of deposits?***

*Yes=13*
*No=1*
*N/A=1*
**Consensus reached**

***Comments***

***Panellist 6***
*I disagree with considering the post cleaning evaluation of materials only as a knowledge tool. If it would be so, and in Portugal this is not the practice in any conservation and restoration area, it is precisely there that relevant information could be found that might allow for a different kind of planning, also relating to cleaning. Cleaning is regarded as a basic conservation operation, but it has profound implications on the supports, which defines it as a complex and impact-bearing operation. The incorporation of knowledge from the post cleaning assessment of material behaviour may help in planning conservation operations where cleaning is less frequent and consequently reduced, or even inherently less harmful.*

***Panellist 7***
[N/A] *I don't think I understand your answer* [specifically the part: "On this topic [different types of deposits], we would like to highlight that deposits are not considered in this procedure, as effectiveness is presupposed"]

***Panellist 13***
[Yes] *One assessment which could be introduced is the time of the restoration. Normally every work has to be done until yesterday and this stress will leave all ratings higher. Also money will influence the results. It could be including low, medium and high budget as assessment points.*

**Answers to Panellists**

Regarding the comment by Panellist 6, we agree that, with each intervention, more knowledge is built on the post-cleaning (or post-conservation action) behaviour of materials. Introducing an assessment stage after the cleaning intervention will benefit future interventions, and in this regard it may offer one more source of information, but it is not an operational instrument for planning the actual intervention, therefore we think that there is no appropriate place to include it in this methodology.

As for the doubts of Panellist 7, the sentence meant that considering the different types of deposits is relevant when searching for potentially effective cleaning methods. Our methodology comes in the succeeding step, when selecting the least potentially harmful method among those elected as effective.

Finally, we agree that time and budget may impose severe constraints in restoration works, and this is why these aspects are considered in the 'Quality components', under 'Logistics'. We are, nevertheless, unable to parameterize these items due to their contingency.

## Cleaning risk matrix: Delphi debate

***48. Do you agree with the changes to the introduction of this section?***

*Yes=14*
*No=1*
**Consensus reached**

***Comments***

***Panellist 7***
*I think the text on this note* [paragraph immediately before the matrix] *is unclear and confusing when introduced here; I suggest that it is moved to the end and simplified.*
*In fact, the potential risk (IR) is a number that corresponds to a xy position in this system ... and the note is about not using this number but expressing it as VxD instead.*

**Answers to Panellists**

The referred note was not only confusing but also redundant, so we opted for its deletion.

| ***49. Do you agree with the changes to the matrix?***<br>*Yes=14*<br>*No=1*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 8***<br>*I think that for the "highest significant surfaces (including those where traces of polychrome are still present)" It is much better to be over-prudent than to be less prudent.* |

**Answers to Panellists**

We of course agree with the Panellist, and that is why 'Very high' risk zones were kept and an 'Extreme' risk zone to cope with those surfaces was created in the 2nd round.

| ***50. Do you agree with the explanations offered on why method effectiveness is not considered?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 3***<br>[Yes] *effectiveness is always related to the degree of cleaning which is seen appropriate for the object by the advisory panel.* |

**Quality components: Delphi debate**

| ***51. Do you agree with assigning risk-multiplying factors to the parameter groups?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 9***<br>[Yes] *I find it very good that weights were assigned. This lets you use the matrix in countries with different contexts and realities. This way, it is not as "100% optimistic", as another panellist said in the first round evaluation.* |

| ***52. Do you agree with the multiplying factors chosen?***<br>*Yes=13*<br>*No=2*<br>**Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 7***<br>[Yes] *but I think it is more reasonable to rate Planification* [now Logistics] *between 1 and 5 (like Team Skills).* |
| ***Panellist 9***<br>[Yes] *Especially with "Team skills" – a serious problem here in my country. When inspecting, we always have to tell the operator how to do a particular procedure, something that would not be necessary if there was adequate competences.* |
| ***Panellist 13*** |

| |
|---|
| *As a wrong significance analysis and deposit impact assessment could lead to a total wrong cleaning method, these points have to get multiplying factors from 1 to 5.* |
| ***Panellist 15***<br>*There's no explanation as to why some are 1-2, others 1-3 and some 1-5* |

**Answers to Panellists**

The choice of multiplying factors was largely based on the concerns expressed by the Panellists on the First Round; a great importance was assigned to the operator skills and therefore we considered it the most influential parameter. Since only two Panellists objected, we consider this topic validated by consensus.

We should nevertheless mention that the objections cited above are of course legitimate, since the chosen multiplying factors are essentially as subjective as the ones now suggested by the Panellists.

| ***53. Do you agree with naming this section 'Quality components'?*** |
|---|
| ***Yes=14***<br>***No=1***<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 5***<br>*Personal note: the attempt to improve the risk assessment of a cleaning operation is deserving, but me too (as the other above mentioned panellist) think it's scarcely realistic this part that concerns the 'Quality components'.* |
| ***Panellist 9***<br>[Yes] *I find it great, also because it will help raise awareness among managers, since quality is something everyone wants. And to associate the importance of projects to quality is essential and this is a way of tying one thing to the other.* |
| ***Panellist 13***<br>[Yes] *I think this is an assessment which could be used in Europe, USA, Japan, etc. but not in the countries like mine. We don´t have these possibilities of methods, in analysis and work, we don´t have persons trained in it, etc. For us it is a dream.* |

**Answers to Panellists**

As for Panellist 5, we cannot offer any guarantee that these 'Quality components' will be used as suggested here. It is an exercise that we think worth sustaining, in spite of its possibly scarcely realistic appearance, to raise awareness for the importance of considering these issues, as mentioned by Panellist 9. Being a dream for Panellist 13, we will find rewarded to have the procedure helping a dream becoming true.

| ***54. Do you agree with the adding of the 'Planification needs' component group?*** |
|---|
| ***Yes=12***<br>***No=2***<br>***N/A=1***<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 3***<br>*Yes, but the term "planification" is not clear. "Planification" is not known in leo.org online dictionary. I would suggest the term "execution of work".* |
| ***Panellist 7***<br>[Yes] *one* [of the items in the group] *was not straightforward, but it is a matter of phrasing.* [The Panellist disagrees with the term 'constraints' in the first item] |
| ***Panellist 9***<br>[Yes] *An extremely important item was inserted, which is the Pre-Diagnosis/'Documentation of the conservation condition' item, another aspect that is under developed in my country.* |

| |
|---|
| ***Panellist 13***<br>*This is not part of an assessment of a cleaning method.* |
| ***Panellist 15***<br>*It sounds like a buzzword!! Logistics would have worked just as well.* |

**Answers to Panellists**

The term 'constraints' was removed, as indeed 'Adequacy of time and budget constraints' seemed slightly incongruous.

Regarding the comment by Panellist 13, we should underline that, ultimately, this Procedure is about assessing a cleaning operation, which includes the method proper but also many other elements, as we tried to cover in it.

The term "Planification needs" was replaced with 'Logistics'.

| |
|---|
| ***55. Do you agree with the insertion of the footnote on cleaning tests in the table Guidelines?***<br>*Yes=14*<br>*No=1*<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 5***<br>*I believe that the preliminary cleaning tests are very important. In fact, the response of a stone surface to a cleaning method, rather than another, is almost always unpredictable. For this, in the 'Guidelines', the importance that these tests should be carried out should be more stressed. These tests should be systematically included in the operational plan and in the budget plan.* |

**Answers to Panellists**

A slight wording change was made in the referred sentence.

| |
|---|
| ***56. Do you agree with including "documentation of the conservation condition" under 'Preparatory' components?***<br>*Yes=13*<br>*No=1*<br>*N/A=1*<br>**Consensus reached** |
| ***Comments*** |
| ***Panellist 5***<br>*It could be useful but not strictly necessary.* |
| ***Panellist 9***<br>[Yes] *I find it fundamental, as I said previously* [see question 54]. |

| |
|---|
| ***57. Do you agree with adding "(consider historical/aesthetical/chemical/physical/ social/other impacts)" to the 'Deposit impact assessment' item?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
| ***No comments were made.*** |

| |
|---|
| ***58. Do you agree with the adding of 'Product adequacy' under the 'Planification' component group?***<br>*Yes=15*<br>*No=0*<br>**Consensus reached** |
| ***No comments were made.*** |

| ***59. Do you agree with adding the 'consideration of future uses' to the table Guidelines?*** <br> *Yes=15* <br> *No=0* <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 7*** <br> [Yes] *actually, it is not only the use that is relevant, but also the new condition of the object, after cleaning, in relation to its surroundings.* |

| ***60. Do you agree with highlighting the definition of reference surfaces under the 'Adequacy of control methods' subcomponent?*** <br> *Yes=13* <br> *No=1* <br> *N/A=1* <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 5*** <br> *See my previous comment on preliminary tests.* [Question 55] |

**Answers to Panellists**
Please see our answer to Question 55.

| ***61. Do you agree with our reasoning that making intervention reports compulsory is too specific for this planning procedure?*** <br> *Yes=15* <br> *No=0* <br> **Consensus reached** |
|---|
| ***Comments*** |
| ***Panellist 7*** <br> [Yes] *but it does make sense to include somewhere in the Procedure the concerns about analysing past interventions as a means of iteratively improving these actions.* |

**Answers to Panellists**
Being a possible source of knowledge, the archival research would be useful. Our feeling is that its impact in the final cleaning risk is covered by the range of error of all the other more influent parameters and we are reluctant to suggest an action that has a marginal influence in the overall process.

## Document 5: Final Built Heritage Cleaning Incompatibility Risk Assessment Procedure

**Assessment Procedure – Introduction**

Whenever deposits are believed to be actually or potentially damaging to the significance of a given heritage object, and/or when necessary conservation treatments call for a deposit removal, a cleaning intervention may be decided upon. One of the most determining factors in this decision is whether or not the risk of cleaning outweighs its benefits. While the overwhelming variety of possible combinations between objects, deposits and environmental conditions precludes a deposit risk assessment procedure to be designed, a cleaning risk assessment may provide helpful guidelines on how to proceed in choosing and planning the less harmful way of removing the undesirable deposits.

The idea behind this risk assessment procedure is to provide the planning of stone heritage cleaning with a tool of straightforward usage that nevertheless encompasses the complexity of the issues involved.
Please note that the procedure described below does not allow for deciding whether or not to clean. The intention of cleaning is presupposed and the procedure concerns uniquely its planning phase. Even if the planner concludes that the risk is too high, there is no form of comparing the results with the non-cleaning option (this would require analysing the impact of different deposits on the significance and on the material condition of the object.)

The effectiveness of the cleaning method in deposit removal is also presupposed. The idea is that, given the deposits and the target surface, a group of cleaning methods is chosen which can then be assessed in terms of cleaning compatibility by using the current procedure.
The objective of this methodology is the assessment of the risks that a cleaning intervention may present to the significance of a given heritage object, and so it presupposes that the effectiveness of the method(s) has previously been established. This risk assessment aims at providing some planning guidelines on how to choose the less incompatible option. Therefore, it is largely about harmfulness, and not about effectiveness. In this context, the main identified incompatibility risks (or incompatibility damage) are: (i) undesirable mass loss; (ii) discolouration; (iii) indirect damage (e.g. caused by clay swelling, infiltrations, etc).

Risk is defined as the multiplication of the likelihood of damage occurring and the consequences of that occurrence; in this case:

$$Incompatibility\ Risk\ (IR) = Likelihood\ of\ damage \times consequences\ of\ damage$$

There are several factors of risk in a heritage cleaning intervention, influencing both classes in the equation above. For the current procedure, these factors were divided into 'hard' and 'soft': the 'hard' factors correspond to items that may be parameterized and semi-quantitatively evaluated, whereas the 'soft factors', due to their strong human component, are more difficult to translate into gradable parameters.
'Hard' factors are dealt with in the first sections of this assessment procedure: (A) the vulnerability of the target surface to cleaning, (B) the aggressiveness of the cleaning method, (C) the synergistic effects that may occur with specific method/substrate combinations, leading to a risk increment, and (D) the impact on the significance of the object. The first three factors are considered to influence the likelihood of damage occurring, whereas the consequences of such damage are assessed via the evaluation of the ensemble of values, i.e. the significance, of the object. Analytically, using a simple aggregation rule common in semi-quantitative risk analysis:

$$IR = [(A)\times(B)\times(C)]\times(D)$$

where:
$[(A)\times(B)\times(C)]$ = likelihood of damage
$(D)$ = consequences of damage

Computing the different factor assessments should therefore permit the planner to obtain an insight on the level of risk involved in the choice of each cleaning method.

The 'soft factors' are related to components such as 'conservation team skills' or 'control', and are dealt with in the 'Quality components' section. These 'soft factors' are sources of risk that also influence the likelihood of damage occurring, and their effect must be acknowledged, even if their assessment is somewhat less defined.

**Assessment Procedure – How to use**

After selecting the intended target surface for the concerned object, as well as which cleaning methods will effectively reach that target surface, it is then a question of choosing the method that will minimize the risks of damage.
As highlighted earlier, this risk assessment procedure starts with the analysis of four factors: the Vulnerability of the target surface; the Aggressiveness of the method; the Synergies between substrate and method; and the Impact on the significance of the object. When analysing these factors, bear in mind which risks the analysis refers to, as listed earlier: (i) mass loss; (ii) discolouration; (iii) indirect damage.
Please note that some factors used in this procedure are inherent to each object: the Vulnerability of the surface, as well as the Impact on Significance, depart from the evaluation of the object, and therefore, once assessed, are to be taken as fixed parameters. What may be changed is the chosen method, and by repeating the procedure with different methods it is possible to compare the different cleaning risks.
When preparing to apply the procedure, start by observing if there are differences within the object in terms of Vulnerability and/or of Significance:

- are there areas with localized increased cleaning difficulties?
- are there any particularly fragile areas?
- are there areas with different significance features (e.g. a plain wall and a decorated portal)?
- etc.

If the answer to any of these questions is yes, then define different representative areas – a risk assessment will be needed for each one. Then, select the cleaning methods that will prove effective for each area; resorting to experience, bibliography and/or expert consultation and cleaning tests in small secluded areas is advisable. Finally, follow the Cleaning Incompatibility Assessment Procedure along the following pages.

In the assessment of the four different ('hard') factors, evaluation scales are used that vary according to the need for distinguishing between the parameters that define each factor: Vulnerability and Impact on significance have their parameters rated between 1 (lower risk) and 5 (higher risk), whereas for the Aggressiveness parameters it was found that classifications between 1 (lower risk) and 10 (higher risk) would allow for a more accurate discrimination of the different methods; finally, the Synergies are considered as risk increments that should be classified between 1 (minimum increment) and 2 (maximum increment). In the end, the aggregation of the different factors is achieved via a simple multiplication, to give an idea of the risk level involved.
When going through this risk assessment process, please bear in mind that, within the proposed ranges (the blue bars), any number, integer or fraction/decimal can be chosen, according of course to the situation at hand. The ratings proposed for each factor are presented in the following sections.

**Factor A: Vulnerability to cleaning**

When starting the process of assessing the incompatibility risk of a cleaning intervention, the vulnerability of the target surface should be analysed the first. Both the type and, where applicable, compactness (using open porosity as a parameter) of the substrate should be determined, and its surface condition should be assessed in terms of resistance to a cleaning intervention. Surface decay signs, and particularly actual or potential material losses, from small particles to large scales, including particle adhesion and cohesion, should be analysed in terms of severity of decay and susceptibility to solicitation.

The table below may then be used as an indication of the target surface vulnerability, where higher ratings should correspond to more vulnerable surfaces. After identifying the substrate type on the table (first column), a value should be chosen within the proposed ranges (the blue bars) that matches the substrate surface condition – higher values should correspond to increasingly more fragile conditions. For substrates not explicitly considered, it is suggested that the users try to find the ratings from the similitude of that substrate with any of those here identified. Please do not forget to consult the 'Guidelines' in the end of the table.

**Factor A: Vulnerability to cleaning** should be rated according to substrate type and target surface condition; for any given substrate, its susceptibility to damage increases with the seriousness of surface decay.

| Parameters – Substrate types | Ratings (1 – 5) |
|---|---|
| Granites and gneisses with porosity <2% | 1 – 5 |
| Granites and gneisses with porosity > 2% | 2 – 5 |
| Marbles | 2 – 5 |

| | |
|---|---|
| Dense limestones and sandstones (Porosity <5%) | |
| Medium sandstones (*) (5%< Porosity <15%) | |
| Medium limestones (5%< Porosity <15%) | |
| Very porous limestones and sandstones (*) (Porosity >15%) | |
| Slates and other low grade metamorphic rocks | |
| Volcanic tuffs | |
| Basalt, gabbro and similar rocks | |
| High grade metamorphic rocks | |
| Porphyry | |
| Brick masonry | |
| Ceramic materials | |
| Concrete | |
| Mortars and renders (**) | |

**(*)** Sandstones with siliceous cement may be very resistant. In such cases, vulnerability may start at very low values of 1 or 2.

**(**)** Mortars and renders made with hydraulic binders may be very resistant. In such cases, vulnerability may start at very low levels of 1 or 2.

**Guidelines:**

- The probability of damage increases with surface decay: for each substrate type, within its respective bar, lower values correspond to sound substrates and higher values should be chosen for surfaces showing progressively more serious signs of decay.
- When the substrate exhibits different surface conditions throughout its extension, different representative assessment areas should be defined, since different assessments must be performed.
- Other plutonic rocks, e.g. diorites and other granitoids, should be analysed similarly to "Granites and gneisses".
- When assessing surfaces with multiple materials, such as mosaics, tile pieces or stone intarsia, refer the assessment to the frailest element.

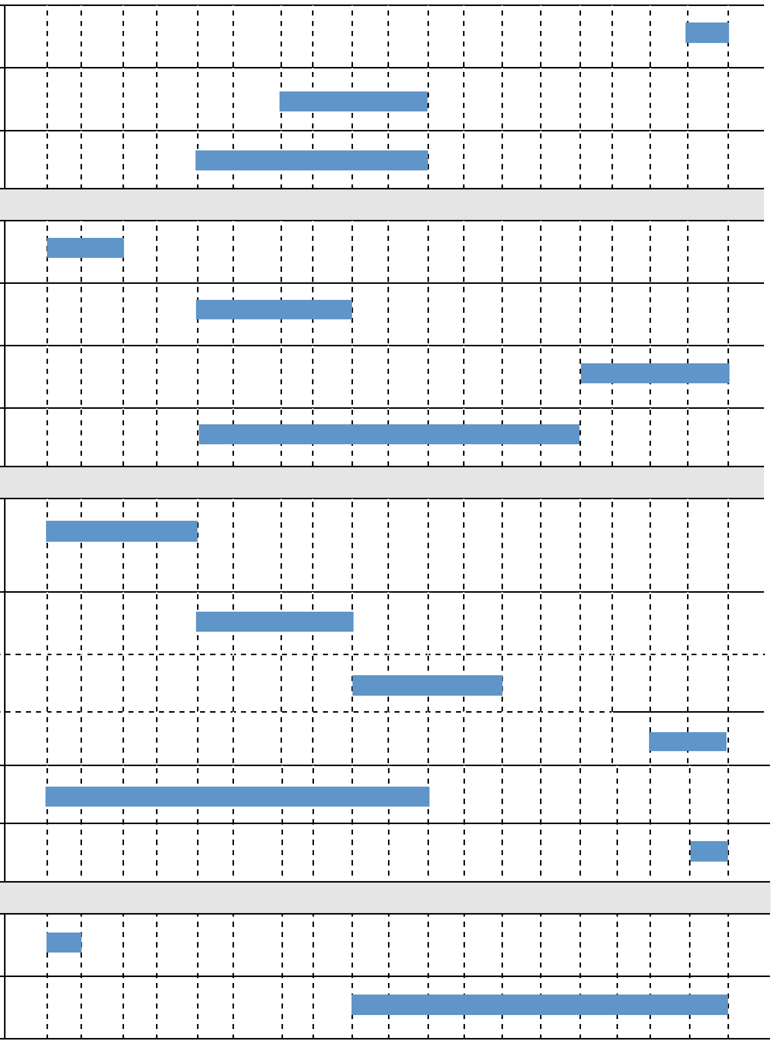
**Factor B: Aggressiveness**

The cleaning method is then ranked in terms of its aggressiveness, i.e., potential to inflict damage regardless of the substrate where it is applied. This aggressiveness is highly dependent on the controllability that the method allows the operator; and on the potential of damaging energy that is forced upon the substrate. Please note that this is an assessment of the baseline risk that the method involves, and therefore it is presupposed that the method is handled by a knowledgeable operator; uncertainty about the operator skills must be considered in the end of this assessment (see 'Quality components'). Additionally, attention is called to the fact that, if using a combination of methods, (full) separate assessments are necessary. The proposed aggressiveness assessment is described in the table below.

**Factor B. Aggressiveness:** each method should be rated according to the controllability it allows for a knowledgeable operator and/or the potential of damaging energy applied on the substrate.

| Parameters | Ratings | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Mechanical methods | | | | | | | | | | |
| Hand tools (chisels, brushes, scalpels and similar) | | | | | | | | | | |
| Particle jet :<br>- spherical microparticles (<0.1mm) set to low pressure (<0.05MPa) | | | | | | | | | | |
| - intermediate particle and pressure values – lower ratings for:<br>- low density particles;<br>- round shapes;<br>- smaller sizes;<br>- lower pressures. | | | | | | | | | | |

| |
|---|
| - high pressures (> 0.5MPa) (particles of any size or shape) |
| Microhammer / pneumatic tools / rotary tools |
| Ultrasounds |
| **Chemical methods** |
| Neutral reagents (6<pH<8), incl. organic solvents |
| Weakly acidic (5<pH<6) or alkaline (8<pH<11) reagents |
| Strongly acidic (pH<5) or alkaline (pH>11) reagents |
| Chelating agents **(*)** |
| **Water-based methods** |
| Without pressure (mist, poultices, sprinkling), with or without soft brushing |
| Water jet: - low pressures (~0.2MPa-0.3MPa) |
| - intermediate values |
| - high pressures (>0.5MPa) |
| Steam jet |
| Wet grit blasting |
| **Laser** |
| Below ablation and discolouration thresholds |
| Above ablation or discolouration thresholds |



**(*)** Chelating agents that form acidic solutions (e.g. $Na_2EDTA$) should also be assessed considering their respective pH as an added source of aggressiveness.

**Guidelines:**

- Methods must be considered alone; if planning to use a combination of methods, separate assessments are required.
- The likelihood of damage decreases with the controllability of the method and increases with its potential of damaging energy. Higher values should be chosen for methods that are increasingly more difficult to control and/or that are applying more intense energies (e.g. larger or denser or more irregular particles, higher pressures, smaller nozzle diameters; higher or lower pH values; higher concentrations, etc).
- When assessing cleaning agents, and particularly chemical cleaners or jet methods, remember that residues left on the substrate, causing staining or soluble salt formation, are also damaging, and the rating should reflect this. Be specially attentive when planning to use aromatic solvents, alkaline cleaners, surfactants or sodium carbonate or bicarbonate jet particles.
- Poultice media (e.g. clay, paper fibres or latex dispersion) are not specified here; the user should refer to the cleaning solutions used (water or chemical cleaning). When the risks associated to poultice cleaning are mostly related to the left residues, the use of a Japanese paper interface will lower them.
- Dry ice blasting should be considered as a microparticle jet (where the particles are solid $CO_2$).
- In jet cleaning with particles or microparticles, low densities chiefly correspond to organic substances and are generally below $1 g/cm^3$.
- Bacterial and enzymatic cleaners should be considered as chemical cleaners.
- When analysing water based methods requiring long contact or dwell times (e.g. poultices) consider the possible induction of biogrowth.

**<u>Factor C: Synergies</u>**

Once the absolute Vulnerability of the surface and the absolute Aggressiveness of the method are evaluated, it is necessary to analyse the synergistic effects that may arise from different substrate/method combinations. Indeed, some features of a given substrate may cause it to be more or less harmed

depending on the method used. For instance, a salt-laden wall may be seriously affected by a water-based method, whereas a purely mechanical method would cause no damage increment in that particular regard. These concerns were not contemplated in the previous sections: (1) the Vulnerability section rated the surface condition, and not the general decay mechanisms, and therefore the presence of clay minerals in the substrate composition or the occurrence of salts are not necessarily accounted for; also, (2) the presence of salts and/or clay minerals, while having a weakening effect on a stone, will not be as threatening for its integrity, especially in terms of side effects, if purely mechanical methods are used instead of water methods. Likewise, an acidic cleaning solution will not have as much damaging consequences on a silicate-based stone as it will on a carbonated stone or render, an issue which is not specifically addressed in the Aggressiveness section. The assessment should bear in mind that effects may manifest immediately or only in the long run.
It was considered that these substrate/method synergies have a risk amplification effect and therefore should be rated between 1 and 2; for example, a rating of 1.2 translates into a final risk increment of 20%. The table below lists the proposed risk ratings to evaluate these interactions.

**Factor C. Synergies:** synergies may occur whenever there is interaction between the substrate and the cleaning method, or an increment of collateral risks.

| Parameters | Increments: 1 | Increments: 2 |
|---|---|---|
| **Chemical methods** | | |
| Causing chemical degradation / decomposition / staining / formation of soluble salts. Examples: | | |
| - acids on carbonated substrates | | ▬▬▬ |
| - strong alkalis on siliceous substrates | | ▬▬▬ |
| - chelating agents on substrates containing Mg or Ca | | ▬▬▬ |
| - mobilization of iron compounds | | ▬▬▬ |
| **Any method requiring water** | | |
| On highly absorbent / permeable construction materials | ▬▬▬ | ▬▬▬ |
| On substrates with soluble salts | | ▬▬▬ |
| On substrates with clay minerals | ▬▬▬ | ▬▬▬ |
| On substrates sensitive to temperature fluctuations when using steam (e.g. marbles) | ▬▬▬ | |
| On substrates sensitive to environmental freezing temperatures | ▬▬▬ | |
| **Any method** | | |
| On polished surfaces | | ▬▬▬ |

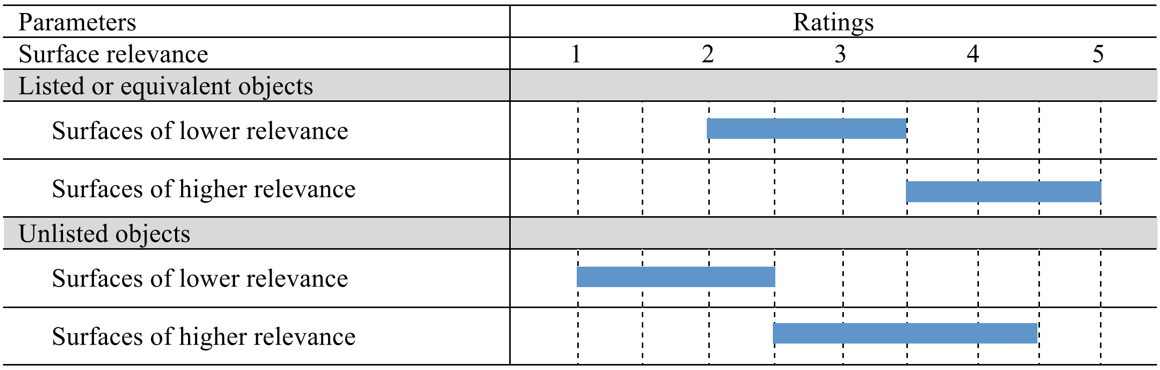
**Guidelines:**
- The probability of damage increases with the interaction between substrate and cleaning agent.
- Polished surfaces may be less vulnerable to mass loss, but any slight modification is easily perceived, resulting in higher visual impacts.
- If the substrate/method combination does not configure the existence of a synergy, then C=1.
- The circumstances listed are cumulative; if more than one specific circumstance coexist, then rate the respective parameters and multiply them (for instance C=1.2x1.5).

**Factor D: Impact on Significance**

Finally, the seriousness of the consequences of damage occurring during cleaning should be assessed. This means asking the stakeholders involved: "How much would the damage of the surface material affect the significance of the object?", i.e., "How relevant is the surface in the overall significance of the object?" Notwithstanding the necessity of a lengthier analysis beforehand, it is proposed that this assessment may be based on the table below.
The table separates listed and unlisted objects, assigning more importance to the former. While acknowledging that many important objects may not be officially listed, it is considered that, among the vastness of objects with cultural significance, some have a higher significance than others, and their listing status was used as criterion for lack of a better option. One should never forget, however, that all objects that come under the current analysis hold cultural significance to some extent, since this method is specific for heritage cleaning. Furthermore, the criteria described below are indicative, and the planner's judgement is advised for cases where values are very high and/or held strongly by a given community, even though the object is not officially listed.
Within each category of objects (listed/unlisted), it is still important to assess how relevant are the surfaces for the overall significance. This may be judged by considering the effects of the loss of surface

material: generally – though not always – losses will have a greater impact on significance if the surface is decorated, or has a particular texture, than if it is a plain building block with no particular surface features. Again, the planner's judgement and stakeholder consultation are advised in order to make sure that no relevant surface features go unnoticed.

**Factor D: Impact on significance**: assessing the consequences of damage means considering how valuable the surfaces are.




**Guidelines:**
- the seriousness of damage consequences increases with the relevancy of the target-surface materials for the overall significance of the object.
- formal aspects such as the presence of sculpted work, carvings or other decoration patterns are generally associated with higher relevance; plain ashlars or rubble masonry may be comparatively (though not necessarily) less relevant for the significance of the object.
- areas of different relevance may coexist in the same object (e.g. pavements and portals); if this is the case, representative areas must be chosen and assessed separately.
- when the surface is part of an ensemble, the impact on the ensemble significance may need to be considered.

**Getting a risk estimate – Cleaning risk matrix**

As highlighted in the introductory section, risk equals the product of the likelihood and the consequences of damage occurring. In this analysis, factors A, B and C are related to the likelihood of damage occurring, whereas factor D assesses its consequences.

The assessment of factors A through D should allow the planner to verify where a given object/cleaning method combination stands – qualitatively, or semi-quantitatively – in terms of risk. It is proposed that the likelihood factors (A, B and C) are aggregated via a simple multiplication and that the obtained value is then cross-checked with the consequence factor (D) in the cleaning risk matrix below. For example, in a situation where a non-significant high density stone surface in a sound condition is cleaned with water under high pressure, then: A=1; B=10; C=1; which means that L=10. For D=1, the cleaning risk is 'Very low'; for a significant surface (D=5), however, the risk would be "Very high", as the potential loss of value is greater.

**Cleaning Risk Matrix Proposal**

| Risk | | Consequences (D) | | | | |
|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 |
| | | **Negligible** | **Moderate** | **High** | **Very high** | **Severe** |
| **Likelihood (L=AxBxC)** | **Very high** L≥40 | Low | Medium | High | Very high | **Extreme** |
| | **High** 20≤L<40 | Low | Medium | High | High | Very high |
| | **Moderate** 10≤L<20 | Very low | Low | Medium | High | Very high |
| | **Low** 5≤L<10 | Very low | Low | Low | Medium | High |
| | **Very low** L<5 | Very low | Very low | Low | Low | Medium |

In simple terms, this can be considered as a 'hard' matrix, meaning that, for a given substrate, the cleaning risk cannot be lowered unless you change the cleaning method. Therefore, risks more serious than 'medium' should immediately alert for the need of a more careful consideration of the cleaning method; reassessments with alternative methods should be tried to see if the risk involved may be lowered.
When no feasible alternative is foreseen for the method under analysis, consider possible risk-minimizing actions, such as reducing the concentration of an acidic solution, reducing the dwell time of a chelating product, interposing a Japanese paper when using poultices, pre-consolidating the surface, etc.

**Quality components**
The table below shows planning Quality components that may help configure an optimal intervention scenario or, quite the opposite, cause the whole intervention to irrevocably fail. Unlike the previously discussed factors, which were rated according to given features of the object or cleaning method, classifying the Quality components depends on if and how they are planned.
The consideration of these components under this section and not as 'hard' factors derives from the evident difficulty on finding the appropriate parameters to rate them properly. These are strongly human-dependent parameters that are best considered as 'soft' parameters, for whose analysis a careful scrutiny is necessary. A careful and considered planning may limit the risk values to those reached with the 'hard' factors, whereas an ill-considered or absent planning will multiply the cleaning risks involved by the multiplying factors proposed in the table below.
In this perspective, these 'Quality components' are to be considered as risk factors that will increase the likelihood of damage occurring. The previous Cleaning Risks Matrix classifications may still be used as a reference once the Likelihood (AxBxC) is multiplied by the Quality component values obtained, and then cross-checked with the consequences (D).

**Quality components:** these are risk-multiplying factors whenever they are neglected.

| |
|---|
| Preparatory – may increase final risk by a factor of **1 to 3** |
| Significance analysis |
| Deposit impact assessment (consider historical/aesthetical/chemical/physical/social/other impacts) |
| Documentation of the conservation condition (to have such a documentation will lead to an easier and more correct assessment of Vulnerability) |
| Defining, characterizing and justifying the cleaning level (*) |
| Required team skills – may increase final risk by a factor of **1 to 5** |
| Adequacy of operators training and experience |
| Experienced conservator-restorers integrated in the organizing and execution teams |
| Adequacy of the team structure |
| Logistics – may increase final risk by a factor of **1 to 3** |
| Adequacy of time and budget |
| Adequacy of the tools, instruments and products available |
| Adequacy of equipment and other supporting means |
| Control – may increase final risk by a factor of **1 to 2** |
| Adequacy of the controlling methods (e.g. timely definition of reference surfaces) |
| Adequacy of the controlling agents |

(*) in cases beyond simpler situations, cleaning tests are advisable at this stage.

**Guidelines:**
- to know exactly what must and must not be removed is crucial; it entails not only a significance analysis, but also how the deposits impact on that significance, in the short and in the long run; future uses must be considered.
- requiring adequately trained and experienced professionals, including conservators-restorers in key organization and execution positions, and ensuring adequate means and team structures are all sine qua non conditions for accomplished cleaning interventions.
- a well-defined and characterized reference surface that will aptly function as a control tool, and was previously agreed with the contractor; as well as adequately trained control professionals, are essential for a satisfactory result.